EP Interrogatory #14

Issue Number: 4.3
Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:
Exhibit D2-2-8, Attachment 1, page 16

Does the Levelized Unit Energy Cost (LUEC) include the cost of interest that will be owed due to rate smoothing and deferral? If not, Can OPG calculate what they will add to the LEUC estimate?

Response

The question makes an assumption that the LUEC would be influenced by decisions on OPG's approach to cost recovery through rates. Rates and LUECs are not the same (see below). The deferral of revenue recovery through rate smoothing, which is what generates the interest costs, does not affect the LUEC calculation. Therefore, OPG cannot calculate what amount the inclusion of interest costs associated with rate smoothing would add to the LUEC.

LUEC is an economic measure used to compare the relative economics of alternative generation options. The calculation of the LUEC utilizes present value techniques to ensure full recovery of all investment, operating and post-operation costs (e.g., decommissioning) over the operating life of the option.

While LUEC can provide an indication of the long-term rate of a generation option over the life of that option required to fully recover the costs of that option, it is not the electricity rate. Because LUEC is "levelized", it is one constant number (usually expressed in a particular year's dollars). LUEC escalates at the rate of inflation.

Annual rates reflect annual specifics such as: (1) fluctuations in generation by year; (2) fluctuations in operating costs by year (e.g., costs are higher in years with vacuum building outages); (3) in-service amounts added to the rate base. These impacts are all "smoothed out" in a LUEC calculation, which represents an average over a full life cycle period.

Board Staff Interrogatory #64

Issue Number: 4.3
Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:
Ref: Exh D2-2-8 Attachment 1, page 2
The above reference states that OPG's current Levelized Unit Energy Cost (LUEC) estimate of 8.1 ¢/kWh (2015$) for the DRP is within the previously communicated estimate of 8 ¢/kWh in 2009$.

a) What total cost can the DRP rise to in 2026$ that would still be equivalent to the LUEC 2009 at less than 8 ¢/kWh?

b) Please calculate the LUEC when the full $12.8B is used.

c) Please calculate the LUEC when the costs related to previous DRP projects that have been moved to Nuclear Operations is added back.

Response

a) OPG interprets this question to be: "to what amount can the DRP cost of $12.8B (which includes interest and escalation) rise, all other factors being equal, and maintain the LUEC at less than 8¢/kWh (2009$)?" The reference to 2026$ is confusing, as the $12.8B is expended over many years in dollars of those years, not in 2026$.

The DRP cost could rise to $16.3B (including interest and escalation), all other factors being equal, and the LUEC for the DRP would remain less than 8 ¢/kWh (2009$).

b) The LUEC of 8.1¢/kWh (2015$) provided in Ex. D2-2-8 Attachment 1 is calculated using the full $12.8B.

c) If the costs for the projects reclassified to Nuclear Operations (see Ex. D2-2-10 p. 10-11) were to be added to the DRP costs, the LUEC would increase to approximately 8.25¢/kWh (2015$).

Please refer to L-04.3-1 Staff-8, part c), and L-04.3-2 AMPCO-105 for the reclassification rationale.

Witness Panel: Darlington Refurbishment Program

Chart 1

Reconciliation of F&IP Project List to EB-2013-0321 Ex. D2-2-1, Tables 3 and 4

Project	Project Number	EB-2013-0321	EB-2016-0152	Total Project Cost based on approved project BCS ($M)
Projects >$20M				
Heavy Water Storage and Drum Handling Facility	31555	DRP	DRP	381.1
Water & Sewer Project	73802	DRP	DRP	57.7
Darlington Energy Complex	73803	DRP	DRP	105.4
Retube Feeder Replacement Island Support Annex	73810	DRP	DRP	40.7
Refurbishment Project Office	73815	DRP	DRP	99.9
Darlington Operations Support Building Refurbishment	25619	DRP	Nuclear Operations Portfolio	62.7
Darlington Auxiliary Heating System	34000	DRP	Nuclear Operations Portfolio	99.5
Electrical Power Distribution System	73821	DRP	DRP	20.8
Projects $5M - $20M				
GM Facility Interim Office Leasehold Improvements	73806/ 73814	DRP	DRP	9.3

In addition to the projects in the table above, the following projects were reclassified as Nuclear Operations Portfolio projects:

- Emergency Service Water Pipe and Component Replacement (Project 73397, Ex. D2-1-3, Table 2d)
- Primary Heat Transport Pump Motor Replacements (Project 73566/ 80144, Ex. D2-1-3, Table 1)
- Primary Heat Transport Pump Motor Overhaul (Project 73566/ 80144, Ex. D2-1-3, Table 1)

- Highway 401 & Holt Road Interchange (Project 73706, Ex. D2-1-3, Table 1)

2.4.5 Project Variance Explanation

This section provides an explanation for F&IP greater than $20M for which total actual or forecast project cost variances exceed 10 per cent. Explanations are provided for the following projects:

- Heavy Water Storage and Drum Handling Facility (section 2.4.5.1)
- Water and Sewer (section 2.4.5.2)
- Electrical Power Distribution System (section 2.4.5.3)

Variances for F&IP are managed as part of the overall DRP. As presented in Ex. D2-2-8, F&IP represent 5 per cent of the overall DRP. There is $76M total contingency in the DRP budget that recognizes the risks associated with F&IP and SIO. The DRP is expected to be delivered on budget and on schedule, notwithstanding the variances described below.

Facility and Infrastructure Projects are significantly different from the Nuclear Operations Portfolio projects that OPG has undertaken in the past and from the unit refurbishment program. They are new designs of complex facilities constructed on a brownfield site. For instance, there are more engineering changes (discussed in section 3.1 of Ex. D2-2-5) required for F&IP than are required for the entirety of the Unit 2 refurbishment.

2.4.5.1 Heavy Water Storage and Drum Handling Facility

Overview

The purpose of the Heavy Water Storage and Drum Handling Facility (the "Heavy Water Facility") is to provide heavy water storage and processing capability for the removal of heavy water from the Darlington units during refurbishment and the management of heavy water during normal operations. Heavy water, when used in a nuclear reactor, becomes radioactive material. As a result, effective management and controls are required to avoid spills and to manage potential radiological safety and environmental consequences.

Interviews with OPG Personnel

May 24-26, 2016

Art Rob – VP Projects & Modifications

- Prior to joining Refurbishment at the Projects & Modifications Group, he completed $200-300 million in work. He used to deliver prerequisite projects for Refurbishment before the project team was setup. He worked on the Darlington Campus (facilities and infrastructure, safety improvement opportunity (SIO)) – initially approximately 20 projects in total.
- When he came into his current role approximately 2 ½ years ago, work was well underway at Darlington. Some of the projects include:
    - In order to complete the building infrastructure upgrades, needed to upgrade power/water distribution. Added two domestic water supplies to the Darlington Campus.
    - Refurbishment Project Office was built; Re-tube & Feeder Replacement Island Support Annex (handles tools and people working on re-tubing job itself); Heavy Water Storage facility.
    - Heavy Water Storage and Drum Handling Facility (D_2O Storage) is a significant project.
    - New Boiler House, safety device, promised as investment to regulator. Protects against potential blackout, serves as a permanent heating device (backup). There was a backup heating device that was built 30+ years ago, but has reached end of its service life.
    - Doubled size of fuel storage building to serve next 35 years of life.
    - Retube Waste Processing Building being built, design allowing for more compact storage. Also, building new Retube Waste Storage Building.
    - The Darlington Energy Complex was also part of Refurbishment projects (done before he joined).
- There are two emergency generators on site today, which will be replaced when the third generator (EPG3) is up and running. Adding a third one allows for more capacity. (Outside of the $12.8B and is part of the sustaining capital portfolio).
- The Infrastructure projects have spent approximately $1.3B, picked up work load in addition to sustaining work load already in Projects & Modifications.
- Regarding contracts, there is an Engineered Services Master Services Agreement (ESMSA), and OPG has pre-qualified two contractors (both previously worked with OPG on nuclear sites). This is the first major endeavor in using outside engineering/engineering, procurement, and construction (EPC) services. OPG made the decision to use performance-based specifications.
    - Had mixed results, took on a lot of work both in-house and for the EPCs.
    - ES Fox (Sargent & Lundy) and Black & McDonnel (RCMP) were the two EPC contractors. OPG added a third, SNC-Lavalin/AECOM.
- In some respects, given the timing and need to begin executing the work, the scope of work may have been "shoe-horned" into existing contracts. In hindsight, had OPG known then what it knows now, the work may have been developed into bundles. In reviewing the work, both sides may have underestimated the scope of work, as there have been lots of complexities and technical discoveries along the way.

- Last spring, there was a look at the investments under the $12.8B estimate, some projects were identified as having nothing to do with Refurbishment. Several projects were reclassified out of Refurbishment to normal capital expenses, did not change how projects were run, but changed how money was tracked.
    - Operation Support Building – gutted and refurbished, originally under Refurbishment portfolio, when finished it was reclassified. Costs/budget moved out of Refurbishment ($55M).
    - Boiler House – really a safety project, also moved out of Refurbishment ($112-120M).
    - Other valve, maintenance type work removed from Refurbishment.
    - Holt Road Interchange Improvements also reallocated.
    - The OPG position is that it is never too late to get projects under right group.
    - These were originally part of the forecasts, out of the $12.8B.
    - As the projects for pre-requisites escalated, there was more of a focus on getting some of the money out of the Refurbishment envelope.
    - Annually, OPG refines the business case.
- The $300M annual spend for Projects & Mods contains hundreds of projects. As part of the learning curve and adjustments in matching with Refurbishment requirements, Refurbishment introduced more rigor and structure into the processes. $300M managed by Engineering group. Refurbishment manages the $12.8B.
    - Reporting goes to each group, depending on the project. OPG is working on consolidating this to one set of reports.
    - Rigor has been introduced into estimating process. The central estimating group is an example. Risk-based contingency development is another example. Now do P90 contingency efforts, before it was expected value or probability "x" impact type approach.
    - Consolidated Front End Planning introduced to ensure the front end work was more robust than in the past (as far as estimating, etc.). Spent more time refining estimates and risk mitigation efforts, putting the right contingency with risk before release.
    - Other big change was going away from an EPC approach and introducing collaborative front end designing. Real-time oversight with engineering up front. Have seen real results in this process.
    - Transition from old processes to new processes is taking place in 2016. The initiative being taken this year is to introduce the gated process for all portfolio work, not just Refurbishment. Also using the Center of Excellence to develop skill improvements (Refurbishment is a large group), focusing on estimating, release strategies, risk reviews, oversight, and using Project Management Institute (PMI) training modules. A big piece of Center of Excellence is the reporting piece. Changing the software to accommodate new reporting processes. Used SAP in another part of the business, corporate decision to use platform used by Nuclear. OPG is working on getting a new system in place and getting people trained. There is now a lot of emphasis on forecasting.
    - Part of the early challenge was using Projects & Mods and existing contractors that were executing existing projects, but adding the Refurbishment prerequisite projects. BOP work still be executed by existing groups.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

1.2.1. Unit Life

Since the Darlington units would have been in service for nominally 60 years by the end of their post-refurbishment lives, OPG has prudently utilized a conservative assumption of 30 calendar years for unit lives in the assessment of the economic LUEC estimate. This post-refurbishment calendar life took into consideration that based on the knowledge gained on pressure tube degradation mechanisms, future pressure tubes will be designed and operated to achieve longer service lives. Thirty calendar years, with an assumed 88% capability factor translates into a pressure tube life of approximately approx. 231,000 EFPH, which is well within the target OPG expects to achieve within the pre-refurbishment life, i.e. 235,000 EFPH.
This conservative life estimate mitigates the risk that unforeseen equipment issues could emerge which could bring about an earlier than expected end of post-refurbishment life.

1.2.2. Annual Station Operating, Maintenance & Projects Costs

Annual OM&A levels were derived based on levels in the current long-term outlook forecast, factoring in changes to work programs and approaches expected over the life of the units.

The post-refurbishment outage costs were developed based on expected work programs and outage templates as well as the long-term outlook forecast. Outage durations and costs were adjusted during the last 10 years of post-refurbishment life to reflect potential equipment aging-related driven need longer outage windows. Outage costs and durations include allowances for periodic 4-unit shutdowns for Vacuum Building Inspections.

On-going sustaining project expenditures (both capital and OM&A) were estimated based on the projected requirements given knowledge and age of the equipment as well as historical investment levels. The forecast also relied heavily on benchmarking Darlington's required investment against those of peer nuclear plants in the U.S (similar vintage, similar size). Given the level of investment during the refurbishment project on each unit, it was assumed that capital project investments, in the first year post-refurbishment, would be 50% of the "typical" annual capital investment level and would ramp up to 100% by the 6th year. In the final 5 years of each unit's life, capital project investments are assumed to ramp down from 100% to 0%. Annual OM&A project investment levels are kept at the typical level throughout the life of each unit.

Table C4 below provides details on the assumptions used for these factors in the analysis.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

Table C4: Annual OM&A, Outages & Projects Costs Used in the LUEC estimate

Cost Factor	Post-Refurbishment Forecast Avg. ($M/yr; 2015$)
Station Base OM&A [1]	290
Outages OM&A [1]	140
Capital Projects & OM&A) [2]	110
OM&A Projects [2]	35
Annual Direct Station Costs [3]	575

Notes:
Costs are rounded to the nearest $5M.
1. Base and outage post-refurbishment forecasts are based on the long-term outlook, and include all Vacuum Building Outages and cost and scope adjustments as the units age. The Vacuum Building Outage Costs were normalized to reflect a planned VBO every 12 years.
2. Capital & OM&A project forecasts are based on the long-term outlook and include adjustments for losses of economies of scale upon the shutdown of Pickering and are informed by benchmarking against peer plants. Periodic major projects (e.g. facilities, security) are factored into the long-term projects forecast.
3. Major costs only. Excludes fuel and fuel-related costs, Minor Fixed Assets, Property Taxes, etc. However, these costs are included in the development of the LUEC estimate.

1.2.3. Annual Support Costs

Costs associated with direct and allocated support services are divided into Nuclear and Corporate Support. Examples of nuclear support include Nuclear Engineering, Fleet Operations and Maintenance and Inspection and Maintenance Services. Examples of Corporate Support costs include Finance, People and Culture, Business and Administrative Services, Legal Support and Commercial Operations and Environment, which includes Regulatory Affairs. In addition, there are centrally held costs, such as insurance premiums, pandemic provisions, past-service obligations for pensions and Other Post-Employment Benefits (OPEB) which are allocated to the Darlington station. Note that past service obligations for pensions and OPEB are costs to the ratepayer regardless of whether the Darlington station is refurbished or not, and, therefore, these costs are not considered in deriving the economic LUEC for Darlington Refurbishment.

Based on the following premises: a) that there are economies of scale in the provision of Nuclear and Corporate Support to a large fleet of stations; b) that there are some "centrally held costs" allocated by Corporate to each station that are purely "fixed", i.e. are not affected by a decision to continue or not continue to operate a station, it has been observed that, as the OPG nuclear fleet shrinks, losses of economies of scale result in an effective increase in the cost of providing Nuclear & Corporate support services to the remaining stations. Because it is assumed that the Pickering units will have already been shutdown by the time that the Darlington Station will be in its post-refurbishment period, Darlington's share of the Nuclear Support Costs and Corporate Support costs will come under upward pressure due to losses of economies of scale. This is evident when OPG's long-term outlook forecast is analysed.

The analysis of Darlington's LUEC estimate, therefore, reflects the expected losses of economies of scale in providing Nuclear and Corporate Support services following the shutdown of Pickering. Table C5 shows the support costs which were assumed in the assessment of the LUEC estimate.

Table 1
Base OM&A - Nuclear ($M)

Line No.	Function	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	Stations									
1	Darlington NGS	277.8	280.1	298.9	314.7	303.1	310.0	318.3	323.1	320.1
2	Pickering NGS	402.3	431.1	425.1	452.1	459.4	469.4	474.1	472.4	478.3
3	Pickering Continued Operations	9.9	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Pickering Extended Operations	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	**Total Stations**	690.0	717.2	724.0	766.8	762.5	779.4	792.5	795.5	798.4
	Support[1,2]									
6	Engineering	148.8	147.6	161.6	178.0	178.5	180.5	183.8	187.5	191.8
7	Projects & Modifications	7.4	6.9	6.3	7.4	6.8	5.8	5.8	5.9	4.0
8	Nuclear Services	75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Fleet Operations and Maintenance	30.5	61.7	63.3	71.0	66.2	63.2	64.6	65.5	66.1
10	Security and Emergency Services	79.9	75.7	81.8	93.9	91.0	91.2	93.4	95.5	98.0
11	Inspection & Maintenance Services	35.4	34.2	34.0	47.2	44.2	42.4	44.2	49.6	52.7
12	Decommissioning & Nuclear Waste Mgmt	0.0	40.0	45.4	49.9	51.8	54.0	54.5	55.6	55.8
13	Other Support	60.7	43.8	43.3	(12.3)	9.6	9.6	9.7	9.7	9.5
14	**Total Support**	437.7	409.9	435.6	435.0	448.1	446.6	455.9	469.2	477.9
15	**Total Base OM&A**	1,127.7	1,127.1	1,159.6	1,201.8	1,210.6	1,226.0	1,248.4	1,264.7	1,276.3

Notes:

1 Nuclear Support Divisions includes Base OM&A expenditures for Pickering Continued Operations of $1.6M in 2013 and $1.3M in 2014.

2 Nuclear Support Divisions includes Base OM&A expenditures for Pickering Extended Operations of $11.0M in 2016 and $1.0M in 2017.

Numbers may not add due to rounding.

Table 1
Outage OM&A - Nuclear ($M)

Line No.	Division	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	Nuclear Stations									
1	Darlington NGS	95.7	56.4	123.8	89.3	131.1	120.7	113.4	145.4	53.1
2	Pickering NGS	77.6	83.0	97.4	116.2	121.3	125.6	120.6	90.5	158.7
3	Pickering Continued Operations	10.2	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	Pickering Extended Operations	0.0	0.0	0.0	0.0	12.2	11.6	20.8	22.8	0.0
5	**Total Stations**	183.5	143.1	221.2	205.5	264.6	257.9	254.8	258.7	211.8
6	**Nuclear Support Divisions**[1,2]	94.0	78.2	92.5	115.7	129.9	135.8	160.5	135.7	96.7
7	**Total Outage OM&A**	277.5	221.3	313.7	321.2	394.6	393.8	415.3	394.4	308.5

Notes:

1 Nuclear Support Divisions includes Outage OM&A expenditures for Pickering Continued Operations of $10.5M in 2013 and $10.7M in 2014.

2 Nuclear Support Divisions includes Outage OM&A expenditures for Pickering Extended Operations of $9.9M in 2017, $25.7M in 2018, $67.9M in 2019 and $62.8M in 2020.

Numbers may not add due to rounding.

Table 2

Capital Expenditures Summary - Nuclear Operations ($M)

Line No.	Category	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	Portfolio Projects (Allocated)									
1	**Darlington NGS**	76.4	164.2	194.4	212.7	176.6	140.9	88.6	37.4	30.2
2	**Pickering NGS**	90.6	96.1	93.4	89.7	23.0	2.4	0.0	0.0	0.0
3	**Nuclear Support Divisions**	24.0	9.5	4.6	14.2	4.6	0.2	0.0	0.0	0.0
4	**Subtotal Portfolio Projects (Allocated)**	191.0	269.8	292.5	316.5	204.2	143.4	88.6	37.4	30.2
5	**Portfolio Projects (Unallocated)**	0.0	0.0	0.0	5.5	48.8	94.6	159.4	221.6	149.8
6	**Subtotal Project Capital (Portfolio)**	191.0	269.8	292.5	322.0	253.0	238.0	248.0	259.0	180.0
7	**Darlington New Fuel**	0.0	0.0	0.0	0.0	0.0	0.0	15.3	0.0	0.0
8	**Minor Fixed Assets**	10.2	22.9	22.3	31.0	26.0	20.0	19.1	19.5	19.3
9	**Total Nuclear Operations Capital**	201.2	292.7	314.8	353.0	279.0	258.0	282.4	278.5	199.3

Numbers may not add due to rounding.

Table 1
Project OM&A Summary - Nuclear ($M)

Line No.	Category	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	Portfolio Projects (Allocated)									
1	**Darlington NGS**	7.2	9.1	19.6	31.3	26.4	25.2	7.6	0.8	0.0
2	**Pickering NGS**	11.4	16.0	7.2	13.4	10.3	11.9	0.0	0.0	0.0
3	**Nuclear Support Divisions**	30.3	17.6	9.1	9.4	4.7	0.3	0.0	0.0	0.0
4	**Subtotal Portfolio Projects (Allocated)**	48.9	42.7	35.9	54.1	41.3	37.4	7.6	0.8	0.0
5	**Infrastructure**	38.4	38.1	64.8	35.8	44.0	37.0	37.0	33.0	29.0
6	**Portfolio Projects (Unallocated)**	0.0	0.0	0.0	(11.7)	13.7	16.1	37.2	47.8	57.9
7	**Subtotal Project OM&A (Portfolio) (line 4+5+6)**	87.4	80.8	100.7	78.2	98.9	90.4	81.7	81.5	86.8
8	**Pickering Continued Operations**	9.2	7.9	2.2	0.0	0.0	0.0	0.0	0.0	0.0
9	**Pickering Extended Operations**	0.0	0.0	0.0	4.0	2.5	18.0	18.4	18.7	0.0
10	**Fuel Channel Life Cycle Mgmt Project**	9.2	8.3	2.3	0.4	0.0	0.0	0.0	0.0	0.0
11	**Fuel Channel Life Extension Project**	0.0	4.9	10.0	15.6	12.3	0.7	0.0	0.0	0.0
12	**Total Project OM&A**	105.7	101.9	115.2	98.2	113.7	109.1	100.1	100.2	86.8

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

Table C5: Nuclear & Corporate Support Costs Used in the LUEC estimate Assessment

Cost Factor	Incremental M$/Yr, 2015$
Nuclear Support	230 (1)
Corporate Support & Adjustments	245 (1)
Total	475 (1)

Note 1: Costs are rounded to the nearest $5M.

The overall post-refurbishment costs assumed, including the amounts in Tables C4 and C5, plus costs for Minor Fixed Assets and Property Taxes, but excluding fuel and fuel related costs, averages $1,070M (2015$) per year, or approximately $1.1B (2015$). This is the figure used on OPG's high confidence economic LUEC estimate.

1.2.4. Station Performance Assumptions

Over several years, OPG has developed and refined its estimate of the performance of the Darlington units in the post-refurbishment period. Numerous factors were considered including performance since in-service of the Darlington plant, specific contributors to incapability in the past and known improvements to maintenance and life cycle management programs. Recent (5-yr and 10-yr average) performance has been excellent, in the 85%-94% range, with the low year of 85% in 2009 coinciding with the periodic planned station shutdown for the vacuum building outage. Recent planned outage performance and forced loss rates (FLR) have also been very good. Darlington is a consistently a top-rated plant in peer reviews.

Factors considered in forecasting post-refurbishment performance include the following:

- Lifetime performance of the Darlington station has been 84.8% capability factor; last 10 years' performance has averaged 89.4% and last 5 years' performance has averaged 89.5%. Most recent year (2014) capability factor achieved was 91.4%.
- As part of the assessment for refurbishment, detailed plant condition assessments (PCAs) were completed. These PCAs have been reviewed and plans put in place to address findings, either pre-refurbishment, during refurbishment or post-refurbishment.
- Technical knowledge of equipment reliability issues, including component degradation mechanisms in CANDU reactors and the balance of plant, has improved dramatically over the past 5 decades of the CANDU program, leading to high confidence that there are fewer unexpected degradation mechanisms to be uncovered in the future.

These issues were discussed in meetings, including senior station personnel and members of the Nuclear Executive Team. The consensus was to assume a reference annual capacity factor of 88% but to analyze over a broad range as shown in Table C6 below.

Table C6: Performance Assumptions Used in the Updated LUEC estimate Assessment

Performance Factor	High Confidence	Medium Confidence	Low Confidence
Gross Capability Factor (%)	83%	88%	93%

The 88% capability factor is lower than Darlington's average performance for last 10 years, which was 89.4%, as well as past 5 year's performance of 89.5%. It is considered a high confidence estimate, given

Numbers may not add due to rounding.

Table 3

Allocation of Corporate Support & Administrative Costs - Nuclear ($M)

Line No.	Corporate Group	2013 Actual	2014 Actual	2015 Actual	2016 Budget	2017 Plan	2018 Plan	2019 Plan	2020 Plan	2021 Plan
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
1	**Business and Administrative Service**	246.6	227.2	231.0	245.0	246.1	239.1	241.0	242.3	246.1
2	**Finance**	46.3	44.4	35.6	40.2	41.5	39.4	39.0	38.8	39.9
3	**People and Culture**	91.6	98.2	95.8	92.4	96.2	95.3	97.8	98.5	100.5
4	**Commercial Operations and Environment**	14.7	19.5	16.8	20.4	20.2	18.9	19.9	19.6	21.8
5	**Corporate Centre**	29.2	26.9	39.6	44.3	44.9	44.5	45.0	45.8	45.8
6	**Total**	428.4	416.2	418.8	442.3	448.9	437.2	442.7	445.0	454.1

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

the station's performance of over the last 10 years. The low end performance of 83% (which is 1.8% lower than the station's since-in-service performance of 84.8%) is a very high confidence estimate, but could result, for example, from a failure to effectively maintain the Integrated Aging Management Program (IAMP) and/or an inability to maintain the current 3-year outage cycle, both considered very low probability outcomes, given OPG's robust management system. An 83% capability factor would also allow for large outages for unforeseen major equipment maintenance during the post-refurbishment period, if necessary. The high end performance of 93% could be achieved if Darlington were to sustain 1st or 2nd quartile INPO performance, funding levels are maintained, the IAMP is effective, and the Management System and currently high Human Performance levels are maintained.

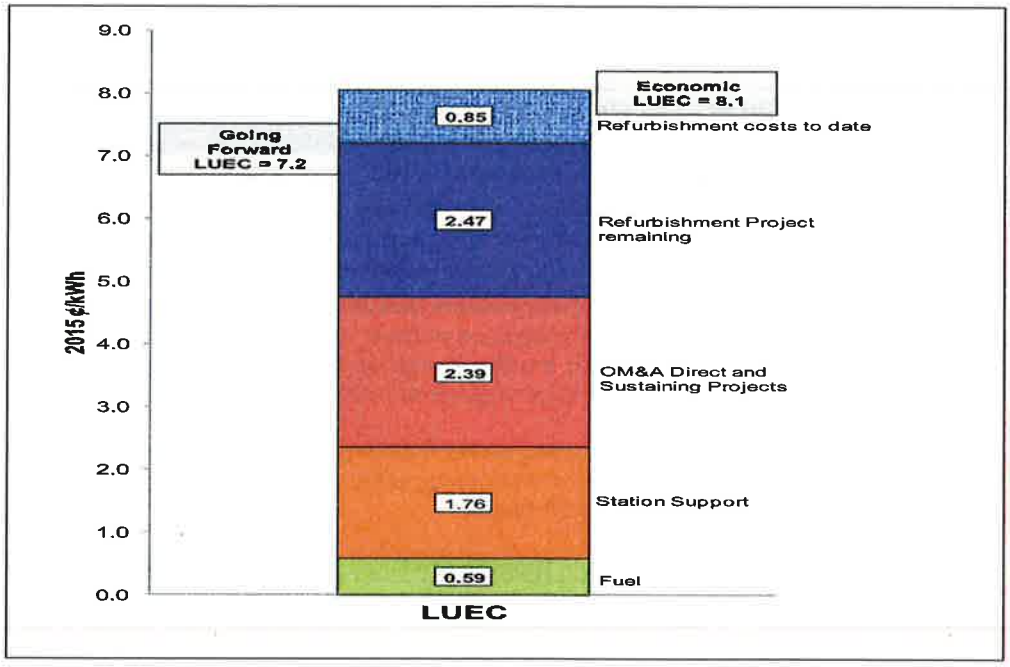
2.0 Results

The high confidence LUEC was calculated using the above assumptions and alternative scenarios and sensitivity analyses were run on lower/higher (more pessimistic/more optimistic) assumptions in order to assess the sensitivity of the results to the various input variables. These results are presented below.

2.1. Levelized Unit Energy Costs

Figure C2 shows the components which make up the current estimate of the LUEC in 2015 ¢/kWh, utilizing the RQE of $10.4B (2015$) and the assumptions regarding post-refurbishment operations costs shown in Table 2. The DRP contributes 3.3 ¢/kWh ($2015), including 0.85 ¢/kWh for DRP costs to-date, to the LUEC estimate, and the post-refurbishment operations and support costs necessary to run the plant, including fuel, contribute to the remaining 4.8 ¢/kWh to the total LUEC of 8.1 ¢/kWh (2015$).

Figure C2: Darlington Refurbishment LUEC Components



Typically an economic LUEC includes only costs that are "not committed", i.e. can be avoided if Darlington Refurbishment were not undertaken. It should, therefore, not include any "sunk" costs. However, OPG has chosen to include the "sunk" refurbishment costs to the end of 2015 ($2.2B), which contribute 0.85 ¢/kWh, in order to ensure that the complete cost picture of LUEC is provided.

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

The "going forward" LUEC of 7.2 ¢/kWh (2015$), represents an economic LUEC at the current time, as this LUEC estimate includes only the incremental costs which would be incurred from 2016 onwards as the project proceeds.

Figure C3 shows the percentage contributions of each of the cost components to the LUEC. The Refurbishment Project makes up 40% of the LUEC, Direct Station OM&A, Sustaining Projects and Station Support make up 53% of the LUEC, and Fuel costs make up 7% of the LUEC.

Figure C3: Darlington Refurbishment Levelized Unit Energy Cost – Major Components

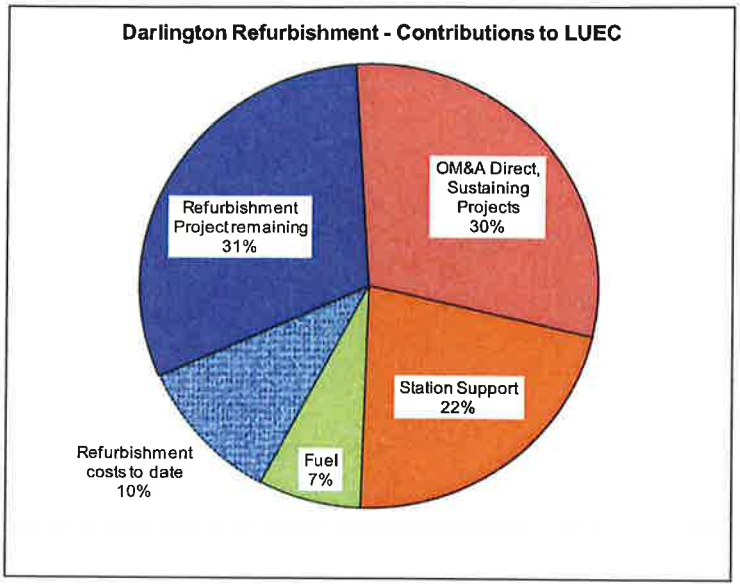


Figure C3 highlights the importance of ensuring that, in addition to delivering the Refurbishment Program on time and on budget, it is critically important for OPG to ensure that post-refurbishment, the station performs to a high level and that the direct and support costs are contained within forecast amounts.

LUEC is a point in time measure and is reflected in today's dollars. Over time, it will escalate with the consumer price index. At 2% CPI, the economic LUEC of 8.1 ¢/kWh in 2015$ would be 10.0 ¢/kWh in 2026$.

2.2. Sensitivity of Results to Changes in Input Assumptions

As documented in Section 1, this assessment includes a large number of assumptions regarding refurbishment costs and durations, going forward operating and sustaining investment costs and operating performance. For each of these factors, ranges were developed and sensitivity analyses were performed at the low and high ends of these ranges for each of the key input factors. Figure C4 below shows the results of the sensitivity analysis. The following helps to understand the impacts of specific changes in underlying assumptions on the magnitude of the Darlington Refurbishment LUEC.

Management has assessed the sensitivity of the LUEC to changes in specific inputs. The following is a summary of the impacts of changes to the key inputs:

i. A $500M increase/decrease in DRP costs relative to the high confidence RQE would increase/reduce LUEC by approximately 0.15¢/kWh ($2015)

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY
APPENDIX C – SUMMARY OF LUEC ASSESSMENT

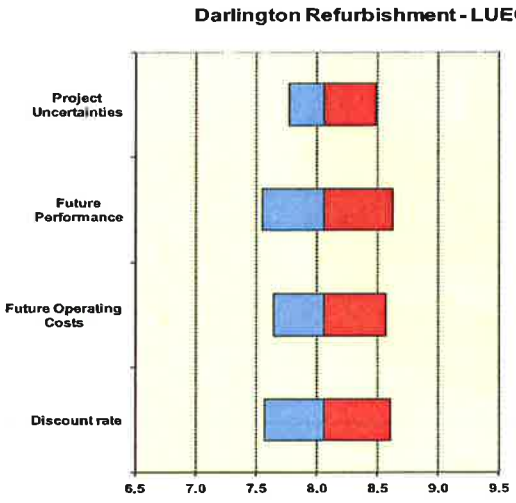
ii. An increase/decrease in overall schedule duration of six months relative to the high confidence duration (1.5 months per unit on average) would increase/decrease LUEC by approximately 0.1 ¢/kWh

iii. A 5% increase in the capability factor (from 88% to 93%) lowers LUEC by 0.4°¢/kWh while a 5% decrease (from 88% to 83%) increases LUEC by 0.45°¢/kWh ($2015)

iv. Each $100M increase/decrease in post-refurbishment annual costs increases/decreases LUEC by 0.4°¢/kWh ($2015)

These impacts on LUEC highlight the importance of managing the DRP within its current high confidence cost and schedule and of addressing the key risks to costs and performance post-refurbishment.

Figure C4: Sensitivity Analysis – Darlington LUEC



Assumptions	Lower	Base	Upper
Project Uncertainties			
Refurb Cost* (2015$)	-10%	$10.4B	15%
Avg Refurb Duration (mths)	-2 mths	39 mths	+3 mths
Future Performance			
Annual Capacity Factor (%)	+5%	88%	-5%
Life of Refurb Units (yrs)	+2 yrs	30 yrs	-2 yrs
Future Operating Costs			
Base OM&A ($M)	-5%	290	10%
Outage OM&A ($M)	-10%	140	10%
Sustaining Projects ($M)	-10%	145	10%
Nuclear Support ($M)	-5%	230	15%
Corporate Support ($M)	-15%	245	10%
Fuel ($/MWh)	-15%	5	15%
Discount Rate	-1%	7%	+1%

*Refurb cost sensitivity applied only to going-forward costs excluding contingency

There are other considerations which contribute to and support the favourable economic assessment for refurbishing the Darlington Station. These include:

- The use of an existing generation site with a proven environmental record and a supportive host community avoids the additional costs to OPG (and ratepayers) of site selection, securing environmental approvals and development of host community support at an unproven green or brown field site. It also avoids the additional costs to ratepayers of establishing a new transmission infrastructure.
- The economic benefits of refurbishing the Darlington Station, in terms of direct, indirect and induced job creation. It is estimated that approximately 2,000 direct jobs are created during the Program Definition and Execution Phases. Continued Operation of the Darlington Station (post-refurbishment) will maintain the same level of employment as is currently associated with the Darlington Station for an additional 30 years. Economic impact studies indicate that post-refurbishment operations of the Darlington Station will result in approximately 5,700 resident jobs in Durham Region (direct, indirect and induced).

In summary, the DRP's high confidence LUEC estimate is approximately 8.1 ¢/kWh, and the going-forward LUEC is approximately 7.2 ¢/kWh. Therefore, Darlington provides a low-cost, stably-priced generation option for Ontario for the future.

damages) will be payable by OPG to the contractor in such circumstances. Examples of direct damages under the contracts (with some variation between the contracts) are:

- work that has been performed to the date of the termination and for which OPG has not yet made payment;
- an equitable portion of any fees which would have otherwise been payable on the next milestone date;
- any contractor costs incurred in providing any work in progress; and
- reasonable extra direct damages suffered by the contractor arising from the termination (such as out of pocket costs for demobilization).

Each circumstance will be dealt with as appropriate based on the facts. There is no special governance process required other than compliance with the contractual terms. Formal communications will be made in accordance with the contract terms; additional communications will be made as appropriate. Prior to terminating any contract, the OPG Project Manager will request a review by OPG's Senior Management team, which includes Finance, Law and Supply Chain.

Upon decision to terminate for convenience, OPG is to provide written notice to the contractor, as set out in the contracts.

b) As discussed in L-4.3-1 Staff-44, beyond being guided by the 2013 LTEP principles for nuclear refurbishment, OPG has no insights into what factors the Government of Ontario would consider in making a decision to direct OPG to take an off-ramp.

Internally, if Unit 2, or any other Unit, was forecasting to be over budget beyond a certain threshold, OPG would be required to issue a superseding business case summary. The superseding business case summary would include information such as updated cost estimates, LUEC, and alternative proposals. The option to take an off-ramp may be one of many considered alternatives. Approval of any superseding business case summary would be sought from OPG's Board of Directors.

c) If a contractor is performing "substantially below expectation", OPG likely would terminate the agreement for default as opposed to termination for convenience.

Performance that is "substantially below expectation" will be determined on a case-by-case basis, but will include evaluation of the contractor's performance on safety, quality, schedule and cost aspects of the work being undertaken as well as their actions, or lack of action, taken to recover the performance gap.

d) OPG expects contractors to be on plan for their work. Recovery plans are required if a contractor deviates from plan and a milestone is at risk of being missed. Steering Committees consisting of senior management from both OPG and the contractor provide oversight on all aspects of contractor performance. OPG expects all defective parts of the project to be corrected at the contractor's cost. In some contracts, a schedule

AMPCO Interrogatory #74

Issue Number: 4.3
Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:
Ref: D2-2-7 Page 8 Chart 2

Preamble: Of the total $1.7B of DRP contingency, $694.1M (40%) is attributed specifically to Unit 2.

a) Please provide the DRP contingency allocated to Units 1, 3 and 4 on the same basis as Chart 2.

b) Does the Monte Carlo analysis differentiate between Units?

c) If the contingency for Unit 2 is not used, please discuss how the funds will be treated and if any remaining contingency funds will be reallocated to other units.

d) Please provide the amount of Unallocated Program Contingency allocated to Unit 2.

Response

a) An allocation of contingency to Units 1, 3 and 4 on a similar basis as shown in Ex. D2-2-7, p. 8, Chart 2 is not available. Please refer to L-4.3-1 Staff-057 for the allocation of contingency to each of the four units across the Major Work Bundles, Facilities and Infrastructure Projects and Safety Improvement Opportunities, Project Execution and Operations and Maintenance functions and Unallocated Program Contingency.

b) The Monte Carlo analysis performed was a four-unit, integrated analysis. While the inputs were created on a unit by unit basis, only integrated results were produced. OPG did not run an independent unit by unit model (e.g., a Unit 2 model, a Unit 3 model, etc.) as this would not be an accurate representation of the four-unit DRP.

c) If Unit 2 is completed with less than the estimated contingency spent, the contingency would be retained for possible use on other units, based on the risk profile of those units, subject to approval by OPG's Board of Directors, or retained at the Program level until the end of the four-unit refurbishment when the program is complete. This approach is consistent with that outlined by Pegasus Global Holdings for management of unused contingency within a megaprogram (see Ex. D2-2-11, Attachment 3, p. 29).

In the event of any unallocated Unit 2 contingency when Unit 2 goes in-service, the revenue requirement impact of the reduced in-service amounts would be recorded in the Capacity Refurbishment Variance Account and returned to ratepayers in a future term (refer to L-9.2-2 CCC-040).

d) Please refer to L-4.3-1 Staff-057 for the amount of Unallocated Program Contingency allocated to Unit 2.

April 2015

of contractors to perform field execution to high performance standards. This demonstration should be led by the core refurbishment execution team, and encouraged prior to breaker open.

- Tied to execution is the fact a good fraction of the work is first time execution for the vendor, very infrequently performed work or first of a kind method. This refurbishment outage is the first time for the Joint Venture to execute a re-tube and feeder replacement. It is the first time in a decade for B&W to clean the Darlington steam generators. And the equipment and process for the handling and reduction of re-tube radioactive waste is first of a kind. OPG has taken a number of actions to mitigate the risk – the most visible being the full-scale reactor mock-up. The need for OPG to have effective oversight and the ability to identify and respond to degrading execution performance is essential for project success.

- There is confidence that the RQE will be completed on time. However, there is a risk that the JV's target price plus requested contingency will exceed the class 4d estimate by a sufficient amount to have a target price not achieved. OPG and the JV are working diligently to resolve a number of remaining issues. A failure to achieve an acceptable target price will require OPG to implement an alternative plan in a relatively short period of time.

- The performance of the fuel handling equipment during the defueling of the reactor will set the stage for the first phase of the refurbishment outage. The station has an initiative to improve fuel handling equipment reliability. This initiative is challenging, and is being monitored by a station oversight committee and the Defueling Project's senior management oversight committee.

In summary, OPG has the infrastructure and framework for execution of the outage at the time of breaker open. The ability to demonstrate successful execution of projects and initiatives during the next 18 months will be needed to provide confidence in the ability to effectively execute the outage.

There have been several upcoming changes within the refurbishment organization identified this quarter. The President and Chief Executive Officer, Tom Mitchell, has notified the OPG Board of Directors of his intention to resign when a replacement is identified. Glenn Jager has been appointed President of OPG Nuclear and Chief Nuclear Officer. This will continue the current situation of one senior executive having responsibility for both nuclear operations and the Darlington Refurbishment Project. In addition, the Director of Operations and Maintenance (DOM) and the Maintenance Manager have notified the organization of their upcoming retirement. The new DOM will be the fourth in just over two years, a challenge to both knowledge retention and consistent direction within that organization.

- The workshop concept is good and leverages the work ongoing with risk identification since the start of the Project. However, the key to success is how the projects/functions develop appropriate contingency inputs. This is no small task considering the available time and the amount of effort involved. Individuals from the Risk Management Group will work with the project and functional groups to facilitate acceptable input for RQE. However, project and functional personnel must develop the justifiable content.
- When BMcD/Modus began work on the Project, risk was a very low priority for the managers. Over the last year, additional management focus has been placed on developing and rationalizing risks, and management's goals are well known to the project managers. Some groups have embraced risk analysis, but others pockets within the team have produced contingency input merely to meet the RQE deadline; despite effective Risk Management tools, infrastructure and a support organization. RQE will be the test of how deeply the DR Team understands the risk aspect of their work.
- Some of the estimates of the impact costs were not derived using accepted estimating practices—but were based upon the project manager or functional group representative's "gut feel". The calculations for the cost impacts of discrete risks should be estimated and vetted by the Estimating team with the same rigor as the base cost estimates.
- The Risk Management Team will also review all registers to identify and resolve duplicate and overlapping entries. Clarity and precision in the risk descriptions will influence how efficiently this review can be conducted. Eliminating such redundancy only increases confidence.
- The BOP team has a significant challenge. Its major contractor has noted performance issues on Campus Plan projects, nssitating significant BOP schedule and cost contingency in order to have sufficient funds budgeted. That creates problems developing firm estimates and schedules. Nonetheless, absent detailed Construction Work Packages, fairly accurate OPEX for executing some of the BOP work, such as valve repair/replacement, can be employed. To develop the best input for RQE contingency, the BOP team has to rely on creative approaches such as existing DNGS OPEX, SME input and appropriate risk analysis. BOP (and, where necessary, other groups) are working closely with the Risk Team to timely develop acceptable contingency inputs.

The Project Controls team managing RQE is intent on issuing a number of key questions for the team to consider in looking at their contingency. In developing the global, program level contingency, the DR Team should fully consider the following risk areas as part of that exercise:

- ***Address vendors' concerns regarding OPG's role as overseer and integrator of the work***: Each of the vendors have voiced their concern that OPG's history is to provide multiple points of contact during a work cycle, who often provide conflicting information and direction and otherwise interfere with the field work. For the Project to be successful, the DR Team needs to dispel these fears with an optimized Execution Phase organization with clear accountabilities, and ensure that the Station and the Project are fully integrated. To address this, the DR Team has identified a plan to test its Readiness to Execute the work using actual work scheduled in 2015-16 prior to Breaker Open. This plan should be finalized and fully vetted for RQE and tracked with appropriate metrics and targets during the coming year. Nonetheless, for purposes of RQE, these risks need to be fully addressed.
- ***Fully analyze and account for the distinct risks inherent with the performance of Units 3, 1 and 4***: RQE is establishing a control budget for measuring OPG's performance on all four units. While this is sufficient for establishing the control budget's base cost, the full DR Project as it currently is planned actually consists of four separate and distinct execution models: Unit 2 is intended as a stand-alone project; Unit 3 will be completed while Unit 1 is started; Unit 1 will be started simultaneous to Unit 3's completion and completed at the same time Unit 4 is started; and Unit 4 will be "lapped" at its start by Unit 1. The DR Team has embedded certain risks regarding the subsequent units; these should be vetted for consistency and whether they cover the impact, needed resources, and other key factors that could make the execution of the subsequent units different, if not

November 2013

The process itself is well-formulated and should serve the intended purpose. However, the DR Team's execution within the process should be addressed. From our sampling of the process, we have found the DR Team is not consistently developing the materials needed for the GRB's evaluation. Some comments and recommendations are as follows:

Observation from Gate Review Process	Recommendations
Quality and consistency of the materials in Gate packages should be addressed. Gate review packages are often hastily assembled by the project teams and provided to the GRB only shortly before the gate review meetings.	➢ Gate package development should follow the existing schedule and key documents should be delivered well in advance of the GRB. ➢ The quality of the gate packages presented to the GRB would be improved by timely delivery of materials prior to pre-vetting sessions within the Project Team.
Within gate packages, there are requirements for explaining variances in cost estimates, there is no formal controlled process for presenting these changes. We have generally found little consistency between the various files kept on the bundles, and in some cases, the estimates used for gate reviews were not preserved.	➢ Improve record keeping and chain of document retention. ➢ Provide a reconciliation of the estimates presented with the gate package to prior estimates (i.e., 4b, 4c) and the basis of estimates so that changes can be traced and sources are identifiable. ➢ Provide an estimate reconciliation within the standard gate package template. ➢ The estimates developed for evaluation at the gates should follow the same general vetting methodology and adhere to the same quality and consistency standards described in Attachment C.
Although designed to provide a forum for challenging scope and cost estimates, the gate review process has thus far had mixed results for that purpose.	➢ In addition to Project Controls, the DR Team should consider utilizing a 3rd Party (e.g., Finance and the Controllership) to provide an independent analysis and examination of the sufficiency of the gate packages. The 3rd party can report to the GRB its findings and concerns.

Now that the Project's scope has essentially been determined, the Team's focus should turn to fully supporting the work that will be done in the Gate Process. We have recommended to Management the need to drive down to the lowest levels of the DR Team the importance of schedule and cost consciousness. Senior Leadership has accepted these recommendations and is implementing changes to the process that should address these concerns.

D. Assessment of Contingency and Management Reserve

BMcD/Modus undertook a review of contingency to determine how discrete risk elements are accounted for in the 4c Cost Estimate. Our review found that while risks are being identified and analyzed in a reasonable manner, the value of individual risks are not directly traceable or otherwise transparent all the way through the estimate to the bottom line. Instead, management has made a decision to carry Monte Carlo Output risk amounts at a more global level, namely, at the project bundle level only. As a result, discrete risks and associated amounts are merely subsumed into a single contingency number with no tractability back to the individual risk elements.

BMcD/Modus has the following observations regarding the methods the DR Team is using for establishing and managing contingency and management reserve:

EP Interrogatory #12

Issue Number: 4.3
Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:
Exhibit D2, Tab 2, Schedule 7, page 5

1. Does OPG have a list of other major infrastructure projects that have used the Palisade software to establish their contingency?

2. Is OPG aware of any cost overruns at projects that have used the Palisade software to establish their contingency?

Response

1. No. However, information on the industries and types of applications where Palisade's @Risk software has been used can be found at Palisade's website.

   @Risk is a widely used software in many industries to perform risk analysis including Monte Carlo analysis and decision tree analysis. It is not only used for major infrastructure projects.

   The Palisade website states that they have been in business for over 30 years, have 150,000 users, including 93 Fortune 100 companies.

2. OPG is not aware of cost overruns at projects that have used the Palisade software to establish their contingency.

feedback is heard. He personally oversees the development and evolution of every one of the fifteen software products Palisade sells. Prior to Palisade, he was a risk analysis consultant.

Roy Nersesian

Professor
Leon Hess Business School at Monmouth University

Roy Nersesian is a professor at the Leon Hess Business School at Monmouth University in New Jersey. He is the author of *Energy Risk Modeling* published by Palisade Corporation. This book is an outgrowth of his teaching energy modeling at Columbia University. He is also the author of *Energy Economics* recently published by Routledge.

David Robertson

Enterprise Risk Management
Duke Energy

David Robertson has over 18 years of experience in regulated utilities, manufacturing, public accounting and financial accounting. He specializes in drawing upon many disciplines to find creative solutions to complex problems. At Duke Energy, David is responsible for the completion of the Enterprise Risk Assessment, an annual presentation to the Board of Directors that outlines the top risks to the company, and the development of the company's risk registers. David has a background in economics and engineering. He is a licensed Certified Public Accountant (CPA) and holds a Master's of Business Administration (MBA) from Wayne State University

Mark Rudd

President
Rudd Asset Management

Mark Rudd is President and Founder of Rudd Asset Management (RAM). Based on a strong technical background, RAM applies proven risk management techniques to a variety of assets. In addition to energy project consulting and development, RAM provides risk management analysis for investments, and financial projects. Drawing upon an MBA from the University of Chicago and over 12 years as a commercial realtor, Mark Rudd is experienced in doing real estate project analysis and financial modeling.

N. Ryan Smith, P.Eng

Manager - Project Risk Management
Ontario Power Generation

Ryan Smith is a Professional Engineer with 15 years of project management experience in a diverse set of roles for both contractor and owner organizations. Ryan's project management interests revolve around the strategic and intangible aspects of the project work, including organizational effectiveness, leadership, and risk and decision management. Most recently, Ryan was assigned to establish and implement from the ground up an industry leading project risk management program for the Nuclear Projects organization at Ontario Power Generation and develop the life cycle contingency estimate for the 10 year $12.8 billion refurbishment of four nuclear units on the shores of Lake Ontario.

JD Solomon, PE, CRE, CMRP

Vice President
CH2M

JD Solomon is the Vice President with CH2M and serves as a senior consultant focusing on risk, reliability, and strategic decision making. Some of his areas of practice include infrastructure health and prognostics, financial management, operations and maintenance (O&M) optimization, and master planning. He is a Certified Reliability Engineer (CRE), Certified Maintenance and Reliability Professional (CMRP), is certified in Lean Management, and is a Six Sigma Black Belt. JD has a Professional Certificate in Strategic Decision and Risk Management from Stanford, an MBA from the University of South Carolina, and a BS Civil Engineering from NC State.

Alejandro Uribe

Wholesale Market Planning Leader
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Alejandro is a Mechanical Engineer with a Master in Systems Engineering (National University of Colombia). He has worked in the electricity sector since 2001. He has worked for the Electricity Market Administrator (XM), and for several utility companies in Colombia. Currently he works as Wholesale Market Planning Leader at Celsia, a subsidiary of Grupo Argos.

Gustavo Vinueza

October 2013

Table 8 – Target Cost & Fixed Fees

[$ Millions]	Base	Rework	Contingency (adjusted)	Execution Phase Target Cost	Fixed Fee	Subtotal*
Unit 2	[redacted]					
Unit 3						
Unit 1						
Unit 4						

Note: * Escalation not included.

7.6 Risks Excluded From Risk Registers

As per the Agreement, certain risks are not allowed in the Risk Registers as input to the Monte Carlo Model. Due to contractual arrangements, risks are transferred to OPG internal or transferred to JV internal. For example, Excusable Delay is a risk in OPG Risk Register, and Defective Work is a risk in JV Internal Risk Register. These two risks are examples of risks not included in the Monte Carlo Model.

This implies that less contingency will be shown in this Monte Carlo Model, as part of the contingency shall reside with OPG and part remain with the JV. To assess overall contingency, all OPG and JV contingency needs to be considered.

7.7 Impact of Separate Unit Risk Models

The Monte Carlo Model has the 4 units run independently. As some of the units undergoing refurbishment at the same time (overlap) and some of units planned to be refurbished in series, it may appear that these separate risk models do not simulate the big picture. However, the Monte Carlo Model of independent runs is based on the assumption that OPG will make the informed decisions to optimize the breaker open dates for the Subsequent Units. With this assumption, the Monte Carlo Model is portraying the big picture with the contingency profiles of the individual units, .

May 2016

for any project. In addition the status of the reporting needs to reflect future performance and status.

a. Vendor performance during the execution of the refurbishment project is not known, but the initial preparatory projects should be a good source of productivity and performance data.

15. **Change Management:** The Change Management Process is critical to enable visibility of scope and cost changes to the project. Anticipating and trending changes, assessing the impact of these changes, promptly agreeing to the cost or schedule impacts with vendors, and including these changes in the forecast. It is suggested to Trend, Change Order, scope and design changes. The Process should recognize two types of changes, those initiated by OPG, and those initiated by the Contractors as a result of unforeseen conditions or events. There are many examples of these processes available to the OPG team and external help can be sought to address this if required.

16. **Contingency:** Messaging of contingency allowance and "cost at risk" is inconsistent. In some presentations OPG is showing only "vendor cost" as risk, excluding risk of cost overruns for O&M and Project Support. However the Contingency breakdown shows contingency for O&M and Project Support Services. It is suggested that this inconsistency be corrected.

17. **Project Record:** OPG is subject to intense scrutiny by multiple agencies and regulators. For prudency hearings purposes it will be critical to write the facts and evidence that support any cost increases. OPG will need to demonstrate prudent management of risks and cost overruns and the application of best management practices to support the case for any overruns to be passed through to the rate payers. The creation of an "independent" project record (detailed with daily records and monthly reports) will also be critical to protect OPG from contractor claims if required. OPG should appoint an appropriate person(s) to monitor, collect and draft project records and prepare detailed risk assessment reports on a monthly basis in advance of OEB hearings, and in support of any contract claims or future contract settlement negotiations or litigation.

18. **Project Risks:** Several commercial risks should be carefully managed:
    - Vendor material cost increases (prices not fixed in contracts).
    - Schedule Change Impacts (schedule is still live and a potential gap is being created between the current schedule and the contractual schedules). The fact that schedules are not yet resource loaded may also imply changes and bring cost impacts due to changes in resource quantities and cash flow curves.
    - Change Orders have the potential to increase the Target Cost. Scenario analysis should be done to understand potential pessimistic outcomes and have mitigation plans in place.
    - OPG removed risk / contingency from the JV price prior to contract signing on the assumption that "OPG is the best party to manage such risks". Contingency was then

a probabilistic distribution of results (loss distribution). For this process to happen, the user needs the software @RISK, which brings this type of power calculation to the final user.

The calculation is applied for each item to the Duration or the Cost of the program, depending on the bucket where the item is located.

Once each one of the input sheets is filled and calculated, a series of reports were designed and built to support the decision making process and bring easy to understand the information obtained after the simulation process. Adding the probabilistic dimension to the model means that each risk or item included in the buckets aforementioned will have different levels of impact, represented by percentiles. E.g. the risk of a project delay could represent between 30 and 75 days of delay in the project depending on the risk appetite of the user: 75 days will be very conservative (P90) and 30 days will be very optimistic (P10).

Each report added to the model focuses in Cost or Duration, giving the analyst the possibility of analyzing the model from several points of view: Duration uncertainty, Cost uncertainty, Risk Uncertainty, etc., at several confidence levels.

Working with percentiles is regular in this type of models and OPG requested a Drill-down report, which will let the users navigate through the different risks and analyze the components of each one. That means, a given bucket can have 100,000 in P90 risk, and it could be made of several items: Item 1 = $25,000, Item 2 = $70,000, Item 3 = $5,000. Summing up percentiles is not permitted and Palisade and OPG worked in an approximation report called "Summary Report" which automatically adjust each risk's results in order to make this Drill Down report work. This is, again, an approximation of the final results.

2.3 Basic Assumptions for running the model

The model includes some important conceptual assumptions that should be considered for calculation purposes:

- The model has to be run with the latest version of the information, gathered from the SMEs.
- Each item included into the calculation can affect cost, duration of both. There are items that are setup to affect Duration only (Schedule Risks) and others designed to affect Costs only (Cost Uncertainty).
- Each risk is applied to each unit. There are four units included in the program and risks will be detailed individually. If a risk affects 4 units, it should be disaggregated in 4 items.
- A list of bundles has been setup initially for the model to be broke up.
- The percentile defined to be the conservative tail was P90 (90%). It is around this percentile that all analyses were generated.
- The numbers used in the parameters for the distribution are the Post-mitigation numbers. It is assumed that there are no further opportunities for improvement reflected in each item's setup.

2.4 The Process

The process that OPG was following was discussed and refined with Palisade. This design was analyzed in detail during Palisade's Visit #2 and it follows the phases below:

Executive Summary

OPG Management's August 11, 2016 report to the DRC affirms the DR Project remains within the overall RQE control budget of $12.8 billion and that the Project's overall P90 schedule duration has not changed. Based on our review, the Independent External Oversight Team (EO Team) found OPG Management's report to the DRC adequately reflects and is generally focused on the DR Project's current key status points and risks. The process OPG used for developing the Execution Phase schedule has followed accepted industry practices and once complete should provide a good baseline for the Project. We have also reviewed recent output from OPG's assurance programs and find them to be effective.

OPG has accomplished most of its planned readiness activities and, at this time, there are no known imminent threats to Unit 2 breaker open; however, there are issues that require attention that could have a significant downstream impact on the Project if they are not addressed:

- Schedule performance and adherence is an ongoing concern;
- While the technical tools are now in place, cost and schedule trending and forecasting are not mature;
- Aspects of key vendors' readiness for execution are a concern; and
- The Risk Management Program has not been fully embraced as an essential day-to-day management tool.

Evaluation of DR Project Status

The EO Team has identified the following key status points that should be considered for purposes of evaluating the DR Project's health as a whole and for the Board of Directors' approval of management's Unit 2 budget and schedule.

Key DR Project Status Indicators	
Schedule Performance	OPG identified the DR Project's current SPI of 0.91 which equates to being approximately 9-10% behind the Project's P50 schedule (though should not impact the P90 range). The impacts of these delays include late finalization of the Unit 2 Execution Phase schedule, procurement and field preparation that will need to be recovered or mitigated prior to field need dates. The vendors' ability to meet their procurement schedules is a concern. OPG has increased visibility and management attention to resolving outstanding vendor and internal issues.
Cost Performance	Based on all of the available information, the overall Project control budget of $12.8 Billion has been maintained, though the EO Team identifies three caveats: ❖ The final Unit 2 Execution Phase schedule will be completed in mid-September. Until that schedule is completed, issues can materialize that could impact the final Unit 2 budget. OPG Management has reserved the possibility of making changes to the Unit 2 budget until the schedule is closed-out. ❖ Since RQE, $61M of contingency has been drawn and allocated, which translates to a rate of approximately $10 Million/month. While we believe this is largely due to finalizing and updating the Unit 2 cost estimate, this velocity of change would be a concern if it continues past the locking-down of the Unit 2 budget. ❖ Risk and contingency calculations for Unit 2 may change as a result of recent additions to the DR Project's risk register. For example, within the last month, certain technical risks have materialized that could have significantly impacted the Project's critical path. While these issues

BURNS McDONNELL

Report to Darlington Review Committee of OPG Board of Directors

MODUS STRATEGIC SOLUTIONS

	were resolved without additions to the base schedule. This underscores the potential for discovery of changes while a project undertakes a detailed baseline schedule review.
Vendor Performance	[redacted]
Risk Management	Since RQE, OPG has identified a number of new program and project risks. Many of these new risks appear to have been added without benefit of the rigor established during RQE and required Management attention. Key technical risks were identified or revised during the Execution Phase schedule preparation, which are under consideration for Unit 2 contingency calculations.
Safety and Quality	OPG's assurance activities have included identifying adverse safety or quality trends and have been adequate to date.

Project and Program Assurance

The EO Team believes the activities performed by the Project and Program assurance teams have been appropriate and their findings have positively influenced behaviors. The DR Team's Performance Assurance Group (PAG), Enterprise Risk Management and OPG Internal Audit have developed and are executing robust plans for assurance activities. The DR Project's quality and safety trends are being reviewed, tracked and monitored and the Project Team has identified and pursued course corrections.

Effectiveness of OPG Project Team

OPG's Project leadership is displaying its commitment to identifying issues and increasing accountability across all work groups. The OPG Execution Team has revised processes based on the Readiness to Execute and its own OPEX that, on paper, should be effective but must be proven. Ensuring that the vendor and OPG commitments are kept and lines of authority are maintained will be a key contributor to success for the Project.

Strategic Considerations

Based on our independent review of the current DR Project's status, the EO Team offers the following analysis of certain forward-looking risks and strategic considerations as the Project advances to Unit 2's Execution Phase. As a part of our analysis, the EO Team has reviewed and assessed OPG's assurance activities to identify any potential gaps. The risks described below have the potential to challenge the DR Project's ability to maintain the P90 schedule and/or cost.

Risk Area	EO Team Observations
Cost and Change Management	OPG's Internal Audit verified that the DR Team has put into place the tools needed to maintain and analyze cost trends; it is now the Project Team's responsibility to properly use these tools. The Project Team has not been utilizing a consistent process for forecasting the impacts caused by deviations from the plan to overall cost and schedule of any particular project. Moreover, critical information needed from the vendors to prepare accurate forecasts has been suspect or missing. As an example, the DR Team has identified mitigation plans for the late finishing F&IP Projects (D2O Storage Facility, EPG3, CFVS and STOP). Analyzing the full impact of these delays requires the vendors

	to provide accurate information and for OPG to validate that information for its cost and schedule forecasts. The current documented status of these projects suggests a high likelihood that OPG will need further draws against contingency due to extended costs and/or recovery of delays, though the vendors' information (or lack thereof) makes accurate analysis of the extent of delays more difficult. Without robust forecasting, projects have limited ability to estimate the impact of current progress on future completion and, thus, no basis for timely or effective corrective action. On a large and complex project like Refurbishment, this could have a significant impact on the cost and schedule. Going forward, improving the accuracy of cost and schedule forecasts will depend upon the Project Team's use of the available tools, verification of the work in the field and ensuring it is receiving timely and accurate data from the vendors.
Risk Management	Since RQE, the EO Team has seen a broad range of risks added by the Project Team to the risk register. The program and structure is well established and functional. Discrete risks have been clearly identified and represent significant aggregate exposure which must be addressed. However, the Project Team's focus should be aimed at building effective mitigation strategies that can be successfully tracked and executed. The EO Team acknowledges that the OPG assurance teams have identified a number of concerns regarding the Project Team's use of the risk program as a management tool. However, the fact this issue continues to come up is evidence that the Project Team has not fully embraced the Risk Management Program as an essential day-to-day working tool. In our opinion, risk management is just as important to project success as methods used to control cost and schedule.
Vendor Capability and Readiness	To date, the vendors have struggled performing the F&IP projects and in meeting some of their commitments during the Refurbishment Project's Definition Phase. This raises several concerns with respect to the Refurbishment Project, [redacted] Based on our review of the vendor's performance over time, we have made the following observations that could have a significant impact on cost and schedule: ❖ The OPG Project Team has a tendency to "help" the contractors resolve issues in a manner that imposes unanticipated demands on OPG staff. Care must be taken to ensure that the contractors do not unnecessarily rely on OPG and shift contractual responsibilities. ❖ OPG's ability to effectively manage the vendors and anticipate issues depends largely on the quality of the data the contractors provide to OPG. As an example, OPG has not consistently compelled the contractors to provide performance data for its second and third-tier contractors or contractor actual hours, also known as their "burn rates." Such data is critical for assessing the contractor's true performance, assessing productivity and finding troubled areas. ❖ OPG has allowed the contractors to re-sequence their projects, which is generally an indicator of either poor performance or poor baseline scheduling. Accountability suffers when a project loses sight of its original baseline. OPG needs to ensure that the contractors are meeting schedule commitments as the Project moves into the Execution Phase and hold them accountable when the schedule slips. Changing a baseline schedule also makes forecasting much more difficult. ❖ OPG has requested changes to the key vendors' project management teams which the vendors have honored. It will be important to monitor these changes for their effectiveness. OPG's commercial management team is currently understaffed. OPG is in the process of finalizing an RFP process to retain an outside vendor to assist in this regard, to keep pace with the volume of potential commercial issues, which it anticipates will increase after breaker open.

Estimate forms the platform from which the Class 2 Estimate (with an expected accuracy range of -5% to +20%) will be developed for RQE. As discussed below, there are some commercial opportunities OPG must weigh that could impact the cost estimate as well. Given its high importance to the overall project, BMcD/Modus sees OPG arriving at an appropriate comfort level with the Class 3 Estimate as essential to tightening the project's cost estimate, and we would recommend the team take any reasonable time and action needed to reach that level of comfort.

- **Commercial Risks:** The Project Team has taken our recommendation to review commercial incentives and disincentives in the Project's major contracts in light of some changed planning basis and assumptions—including the Shareholder's mandates set forth in the LTEP, the unlapping strategy and the evidence to date of contractor performance. The DR Team took an action to develop a negotiation strategy with SNC/Aecon that will take into account the impact on their work caused by the unlapping Unit 2, prioritization of Unit 2 performance, potential for economies of scale with the Turbine Generator work and other key considerations. Regarding the ESMSA, senior management is instituting a number of changes to managing and executing the EPC model that has proven to be ineffective at driving performance, cost and schedule compliance and reducing OPG's risk. [redacted], and OPG theoretically has both the expertise and the essential knowledge needed to more effectively manage this work. Going-forward, it is OPG's intention to take a much stronger role in managing and directing the engineering portion of the work. In doing so, it will be important to for OPG to understand and communicate the impact of the shifting of risk for this added responsibility as well as any impact to warranties provided by the contractors. The success of this new strategy will depend on OPG's ability to attract and retain talent and OPG's ability to drive change down through its organization to implement a new project management philosophy.

Other ongoing challenges to the DR Project include the development of the DR Team for the Execution Phase, further refinement of the Risk Management Program and Fuel Handling work. Attachment "A" provides an update regarding the DR Project's risks.

II. Summary of Campus Plan Root Cause

A. Overview

The Campus Plan Projects consist of 26 separate scopes of "pre-requisite" work that are needed to support the DR Project or the station's operations during construction. These projects are being managed by OPG's P&M organization. Prior to this Campus Plan work, P&M executed capital projects for the stations, with annual budgets of approximately $300M. With the advent of the DGNS Refurbishment Project, senior management sought to use P&M to develop and oversee all of the Campus Plan Projects, allowing the DR Team to focus on planning for the DR Execution Phase. The inclusion of the Campus Plan Projects caused P&M's portfolio to increase by four to five times, and the scale and technical complexity of this work was unprecedented for this organization. At the same time, OPG was under pressure to decrease its staff in line with the Shareholder's requests. As with many utilities in the US, OPG who had once had a very large construction unit that built the current stations and Bruce, and as recently as Pickering A Unit 1 RTS Project in the mid-2000's had considerable in-house construction, planning, procurement and engineering resources, was shrinking even further and the capability for managing and directing large capital projects was sacrificed.

From 2010 until July 2013, P&M was led by its former VP [redacted]. [redacted] ultimately succeeded [redacted] in January 2014. P&M's governance, including most of its business and management processes, were separately developed and maintained from those used by the Refurbishment Project. Also, P&M negotiated and utilized the Extended Service Master Services Agreement ("ESMSA") contract and the two "ESMSA Contractor" consortiums led by Black & McDonald and ES Fox. The ESMSA contract is actually a mix of multiple standard form agreements that could be used in combination depending on the circumstances – e.g. there are separate forms for engineering, procurement and construction that could be combined into an "EPC" contract. The business deals with the ESMSA Contractors were

the result of a competitive process which resulted in the contractors agreeing to some unique provisions that are used for all contracted work with these vendors. As an example, when used as an EPC, the contractors who lead these consortia are required to bid engineering work on a fixed-price basis with no profit for themselves. The construction work is all cost reimbursable target price, and the performance incentives include up to a 50% reduction of profit, though this and some other disincentives built into the contract have proven thus far to be much less effective in practice than concept at driving the contractors' behavior and performance.

The impetus for having P&M execute the Campus Plan work was that through the Definition Phase of Refurbishment, the DR Team was not assembled as an execution organization, but a planning one. P&M was an existing service resource with some experience in managing the ESMSA contractors. P&M's work on the Campus Plan Projects is funded by Refurbishment and it must report its progress to Refurbishment, though these business units are otherwise autonomous. Until recently, other than these approvals and the fact that both organizations use the ESMSA Contractors, there was very little else in common between Refurbishment and P&M, including the project management procedures utilized for their respective projects. P&M's project management procedures were not developed to manage multi-year projects of the size and scope of some of the Campus Plan Projects. Over the last several months, P&M has begun to manage the Campus Plan projects in accordance with the project management procedures developed for the DR Project in an attempt to implement industry-standard risk, cost and schedule controls. Additionally, the new VP has implemented a series of organizational and strategic initiatives with the goal of improving performance.

As of April 2, 2014, the Campus Plan Projects are estimated to cost in aggregate approximately $660M (an increase of $111.5 Million over the Board of Directors approved 2014 Business Case release for this work) and the work varies widely in size and complexity. The performance of the work is largely split between the two ESMSA contractors, Black & McDonald and ES Fox. Deadlines for completion of these Projects vary based on the project's and stations' needs; AHS is scheduled to be complete prior to the DNGS Vacuum Building Outage ("VBO") in mid-April 2015, while all the remaining work is scheduled to be completed one year later, in April 2016, to allow enough time for commissioning prior to the October 2016 Refurbishment Project's breaker open milestone. Many of these Campus Plan Projects involve the construction of commercial buildings that are made more complex because of their location on or adjacent to the nuclear island, which impacts their associated design requirements for such things as nuclear safety, security, and seismic requirements. Additionally, these are brownfield projects on a site where soil quality issues and underground interferences are the norm and coordination with the operation of DNGS must be managed.

Over the last quarter, BMcD/Modus has engaged in a number of activities related to the Campus Plan Projects. In this regard, we have:

- Reviewed the reasons for significant cost variances in five of the largest Campus Plan and Prerequisite Projects: D20 Storage Facility; Auxiliary Heat System Building ("AHS"); Water & Sewer; RFR Island Annex Building ("RFRISA"); and Retube Waste Processing Building ("RWPB"). Our goal was to determine the root cause of the Campus Plan Projects' variances so that past mistakes will not be repeated. We chose to examine the RWPB, which is being built by SNC/Aecon and managed by the DR Team, for a real-time direct comparison with the ESMSA-managed projects.
- Reviewed the Campus Plan Projects' schedules prepared by the vendors to identify any major gaps. This review led our team to make a series of recommendations to the P&M and DR Teams, and our subsequent monitoring of progress of the vendors' ongoing redevelopment of their detailed schedules for each of the major projects.
- Examined the risk management process within the P&M organization, including its ability to properly identify, avoid, mitigate and monetize risk.
- Reviewed the design and scoping process and identified the causes for the extreme inaccuracy of the vendors' engineering cost and schedule estimates.

an example, for the D20 Storage project, Black & McDonald was told to remove from its contract price any contingency for unforeseen soil conditions, even though there was a high likelihood that there would be contaminated soil issues. Moreover, P&M clearly overvalued price as a consideration in the contractor selection process, especially in light of the fact that the work was going to be performed on a cost-reimbursable basis and the bid prices were not binding.

P&M gave only token consideration to determining which contractor had a better approach for executing the work. P&M chose the "low bidder" even though the other contractor's qualifications and project approach were viewed more favorably. Thus, P&M created the conditions for a perfect storm of cost and schedule overruns. Because the work is largely based on a cost-reimbursable target price with no caps on size, P&M's artificial beating down the contractors' prices in the bid phase was a Pyrrhic victory: P&M's actions did not reduce cost and only served to deprive senior management of realistic cost projections for this work. The budgets for these and other F&I projects were nothing more than paper barriers that were easily surmounted as the design work continued to generate more complex (and expensive) work.

b. Lack of an Integrated Schedule

Until April 2014, the P&M project teams for D20 and AHS were working without a reliable, integrated Level 3 Schedule. Many on the project and throughout the OPG organization were given a false impression that the Campus Plan Projects, and D20 in particular, had a year of float, and so on-going delays had no impact on the Project. The delays to D2O Storage's schedule were not forecasted by the project team and were simply reported after the fact. By this point, the schedule had already slipped so that engineering was on its way to an 18-month projected overrun of an original 11-month schedule. However, without a resource-loaded, level 3 schedule, it was impossible to assess the status of the project, let alone calculate with any accuracy any remaining float.

One of the strategic initiatives was implemented by the new P&M VP was to improve the projects' schedules. This endeavor allowed the project team to see that D20 Storage was actually projected to be completed on April 26, 2016, more than a year after the original April 15, 2015 deadline. Furthermore, once known risks are factored in, it is likely that the D20 project can only achieve this revised date if some of the schedule durations are accelerated—at an additional cost. Even then, these efforts will not improve completion of the schedule by much, but will increase the probability that the April 2016 date can be met. However, none of this would be known if efforts had not been made to improve the schedule.

c. Risk Management

Based on our observations, it appears that all P&M's identification of risks is a "check-the-box" activity due the fact that having a list of risks is a prerequisite to obtaining a funding release. P&M does not actively manage its on-going risks as a part of an effective risk management program. As an example, the risk sections of the D20 and AHS BCSs consist of lists of potential risks and some evaluation of their nature, but it is not apparent that these risks in any way influenced the calculation of these projects' contingency, nor are there any regular reviews or updates of these risks until required to do so in order to pass a gate and obtain a funding release. Once a project obtains full funding for execution, very little, if any, attention is paid to day-to-day risk management, including the ongoing identification of new risks and opportunities as well as the formalized implementation of risk mitigation strategies. Additionally, there is no structured or defined risk program management oversight (such as the NR Risk Oversight Committee).

A recent self-assessment performed by the NR Management Systems Oversight group (SA RF13-000855 dated January 20, 2014) identified perceptions (opinions) of several P&M managers that included the following: "[D]evelopment and use of a Risk Register is seen as purely administrative and not adding value to the Project Managers." This suggests a lack of understanding of the value of a risk management program or lack of acceptance, which can be addressed by effective training and indoctrination. However, risk management training is virtually non-existent in the P&M organization in distinct contrast to several years ago when quarterly workshops were regularly conducted.

- OPG needs to examine staffing and resources. Currently, there is only one dedicated cost estimator for all of P&M's work. The DR Team has already taken action to increase staffing levels and add experienced personnel, and P&M needs to do the same.

- **Project Reporting must be accurate, timely and convey information critical to senior management for decision-making** – As noted, the reports P&M provided to senior management on the Campus Plan projects were inaccurate and not updated in a timely manner to enable prudent decision-making. Our examination of P&M's reporting shows a general desire to produce large volumes of surface-level reports that are completely inadequate for managing the work, all the while P&M ignored such critical metrics as an accurate Estimate at Completion (EAC) and detailed schedule of work. Any tendency to "turn everything green" when such is not the case must be resisted - prudent management of complex projects requires full transparency and visibility of anything that is not going well so it can be addressed and fixed. P&M and the DR Team need to increase the focus on accurate, concise reporting with an emphasis on forecasting.

- **P&M needs to break down the silos**—All of the Campus Plan Projects are being performed by two contractors. However all of the Campus Plan work has been managed as 26 separate projects. All of the project management functions—i.e. schedule, cost and risk need to be managed through an integrated approach so that resources and management focus can be applied appropriately. We recommend that P&M look at its organizational structure to optimize the ability of its project managers to have more direct accountability. This may require more and different resources.

- **Campus Plan Projects will require a full rebaseline of cost and schedule** – Irrespective of when these projects' next gates occur, each of the Campus Plan Projects and, likely, each of the P&M non-Refurbishment projects at DNGS and Pickering, will require a full, bottoms-up rebaseline of costs and schedules. With the examples cited herein, BMcD/Modus cannot ascribe any confidence to any project estimate that was developed by P&M's former regime. Bill Robinson has made this commitment and appropriate focus will need to be applied. P&M needs to perform this reforecast on an urgent basis.

With respect to the Refurbishment portion of the DR Project, BMcD/Modus's monitoring of the BOP work to date shows that OPG has spent considerable time and effort in a robust scope definition process that addresses most of the external OPG stakeholder-driven scope issues in a manner that is consistent with the DR Project's charter. The DR Team has embedded in the organization a Director of Maintenance and a team to work our operational concerns and has an independent Design Authority. Moreover, as stated, the DR Team had already acted to safeguard against some of the problems seen in the early Campus Plan Project, notably; (1) the DR Project's institution more thorough scope definition to contractors via the MDPs the engineering team developed was a direct consequence of the OPEX from D2O Storage from over a year ago; (2) it is also apparent to us that while the DR Team had started down the same management path as P&M, it was able to put on the brakes and change course at a much earlier stage. Nonetheless, in light of our review of the Campus Plan Projects, we recommend that the DR Team perform a detailed self-assessment that considers the ways in which the Campus Plan Projects management failures might apply to Refurbishment.

III. RQE Preparation

With this report, BMcD/Modus will begin a dedicated section for assessing the status of the DR Team's activities that specifically lead to the development of the RQE budget and associated schedule for the October 15, 2015 deadline. With respect to RQE planning, the DR Team has started its specific planning efforts, though soon there needs to be a greater focus on the specific deliverables, the timing of their preparation and a thorough understanding of how the many components will be compiled into a comprehensive estimate. Project Controls has named a manager for this effort and an activity schedule is being developed for incorporation into the Project's plan.

The most imminent upcoming RQE-related tasks relate to the development of the 4d Release Cost Estimate for the 2015 Business Plan ("4d Cost Estimate") that will be prepared for the Board's approval at the November 2014 meeting. The 4d Cost Estimate effort should also provide a template for many of the activities needed for RQE. In this section, we will

May 2014

Attachment C – Summary of Cost Variances to Date for Campus Plan Projects
BMcD/Modus 2Q 2014 Report to NOC
May 13, 2014

In accordance with recommended industry practices, construction project costs should be periodically evaluated and updated in order to develop reliable estimate at completion ("EAC") forecasts. Planning for cost forecasting establishes the timing of forecasts, how forecasts are communicated or reported, methodologies and systems/tools to be used, and specific roles and responsibilities for forecasting. EACs should be prepared and issued on an established schedule that is appropriate for the pace of work on the project.

The development cycle of an EAC typically follows a set process with standard guidelines for the project team to follow. For instance, one step would be to review and rigorously vet contractor cost reports to understand the development of costs versus current budget, planned and actual productivity. Based on our review of five (5) Campus Plan Projects, it does not appear that Facilities and Infrastructure ("F&I") used a set process or guidelines to govern EAC development. When we interviewed the project teams, we discovered that each team was following its own EAC process, indicating that there was neither visibility to cost increases nor internal cost control.

To understand the impact to the project costs and EAC process, we compared the current EAC to the last approved BCS to identify the magnitude of cost increases. The following chart illustrates the cost increases on the projects[1]:

Overall Cost Variances between the Latest BCS and the Current EAC on F&I Projects

Project	Board Approved Costs	Current EAC	Variance	% Increase
D2O Storage & Drum Handling	$ 110,015	$ 314,383	$ 204,368	186%
Auxiliary Heating System	$ 45,607	$ 85,102	$ 39,495	87%
RFR Island Support Annex	$ 32,504	$ 40,738	$ 8,234	25%
Water and Sewer	$ 45,703	$ 57,712	$ 12,009	26%

We then analyzed the project documents to identify the categories of costs behind the increases identified on each of the projects as described below. We also interviewed the project teams to understand their EAC process.

D2O Storage & Drum Handling

Our analysis of the RFR Island Support Annex estimates yielded the following summary highlights:

- On this project, nearly every cost category of work has increased considerably ranging up to +537% above approved gate funds, with the exception of Phase I engineering design and award long lead procurement which was contracted on a fixed price basis.
- Engineering work is 82% complete overall versus a planned completion of 100%; 48 of 84 ECs have been issued in Passport. Engineering is forecasting that all ECs will be completed by early November 2014.

[1] The chart contains only 4 projects because Retube Waste Storage is not included; this project has not progressed beyond the definition phase.

April 2016

11. **Housekeeping:** This is a leading indicator of Safety. This standard needs to be maintained early during the refurbishment, and on an ongoing basis, which will help keep the site in a "safety conscious" mind-set. However, this is bigger than just refurbishment and the station's lay down areas. The station will still have operating units and the world class standards must be applied to the operating units. The standards need to be clearly defined between Refurbishment areas and the Operating Units.

12. **Project Controls and Authority Level:** Integrity and accountability are key components in managing projects and maintaining job scope. Clear spending accountability with respect to decision making needs to be defined. A clear definition of what a "Scope Change" really means is needed ('additional scope' versus what is 'needed to meet scope'). A $100,000 limit if drawing on an established contingency is currently the authorized amount for the project manager to spend, without additional approval. This limit should be reviewed and substantially increased (in our opinion). Expenditures are likely to be much greater, and frequent. The time required under the current process to obtain approval for expenditures will have a substantial impact on critical path. ($2000 per minute is the estimated impact for critical path.) A support mechanism should be in place to relieve the burden, other than initial notification to Senior Management, to process and document the basis for these expenditures.

13. **Risk Management:** The current practice of removing the "topic" that is tracked in the risk management program when the due date is exceeded, or deemed past due, does not address the impact on the refurbishment. It also takes away from the continued importance of the item. When risk is not addressed, cost is the result. In addition, the future impact of that risk item does not 'go away' even though the item is removed from the key risk item list. Keeping the topic of risk on the risk management summary keeps focus on the issue, and provides input to future actions and schedule.
    a. The schedule does not include resource loading and the identification of handoff points. The RCRB believes these present one of the greater risks to the refurbishment schedule, but are not among the most important risk items.
    b. Another potential risk is the new inspection ports to be installed on the Steam Generators. The RCRB recommends that an independent group review the process and the risk associated with installing Steam Generator lancing ports. (Information is being collected to provide to the RCRB). Other high consequence items should be identified and reviewed.

14. **Project Reporting:** The RCRB has seen a significant example where the metrics do not accurately reflect the actual state of the project. Approximately half of the 2016 pre-refurbishment year-to-date budget is not spent. The basis for this under spend is that work is not done. However, the schedule metric also shows performance as 'green.' This situation does not present the most accurate representation of the project. This presents an optimistic view of the project, instead of a true reflection of the status. The appropriate methodology and sensitivity for metrics, as well as the correct interpretation of the metric are critical attributes

Chart 1

Unit Project and Program Contingency

Project	Estimate Class[4]	Project Contingency ($M)	Program Contingency ($M)	Total Contingency ($M)
RFR	2	236	381	617
Turbine Generator	2-3	195	23	218
Steam Generators	2	20	0	20
Fuel Handling and Defueling	3	25	38	63
Balance of Plant	3-5	230	0	230
F&IP and SIO	1-3	42	34	76
Project Execution and Operations and Maintenance	N/A	58	222	280
Unallocated Program Contingency	N/A	0	202	202
Total Contingency ($B)	-	**$0.8B**	**$0.9B**	**$1.7B**

Authorization of the use of contingency funds is strictly controlled through the Change Control Board ("CCB"), which requires an explanation of the risk or uncertainty element that has been realized and a robust approval model that requires escalation for use of any contingency funds. Additional information regarding the CCB is found under Ex. D2-2-9, Attachment 1.

4.2 Unit 2 Contingency Amounts

Of the total $1.7B of DRP contingency, $694.1M is attributed specifically to the Unit 2 refurbishment and forms part of the forecast cost of Unit 2 refurbishment. This includes $339.0M of project level contingency and $355.1M of Program level contingency, which together represent 14.4 per cent (7.0 per cent and 7.4 per cent respectively) of the total Unit 2 in-service additions for 2020.

Allocation of the total contingency across the four units was based on 'risk exposure windows', which refers to the anticipated timing for when the risks or uncertainties would be realized and associated contingency costs would be incurred. In allocating contingency to

[4] See section 2 of Ex. D2-2-8 for further information on estimate classification.

Numbers may not add due to rounding.

Table 2
Capital Project Listing - Darlington Refurbishment Program
Projects ≥ $20M Total Project Cost [1,2]

Line No.	Facility	Project Name	Project Number	Category	Start Date	Final In-Service Date	Total Project Cost ($M)	Partial/Devmt Release ($M)	Initial Full Release ($M)	Superceding Full Release ($M)	In-Service 2016 ($M)	In-Service 2017 ($M)	In-Service 2018 ($M)	In-Service 2019 ($M)	In-Service 2020 ($M)	In-Service 2021 ($M)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
		ONGOING PROJECTS FROM EB-2013-0321														
1	DN	Darlington Refurbishment - Unit Refurbishment - Unit 2	Various	Unit Refurb - Unit 2	2010	Feb-20	4,800.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,799.8	0.4
2	DN	R&FR - Tooling for Removal Activities	73112	Unit Refurb - Early In-service	Feb-12	May-16	87.0	0.0	0.0	0.0	87.0	0.0	0.0	0.0	0.0	0.0
3	DN	Heavy Water Storage Facility [3]	31555	F&IP	Nov-06	May-17	381.1	0.0	110.0	381.1	0.0	365.9	0.0	0.0	0.0	0.0
4	DN	Water & Sewer Project [3]	73802	F&IP	Jun-10	Nov-15	57.7	0.0	40.6	57.7	3.7	0.0	0.0	0.0	0.0	0.0
5	DN	Darlington Energy Complex [3]	73803	F&IP	Mar-10	Jul-13	105.4	0.0	105.4	0.0	0.9	0.0	0.0	0.0	0.0	0.0
6	DN	Retube Feeder Replacement Island Support Annex [3]	73810	F&IP	Sep-11	Oct-15	40.7	0.0	40.7	0.0	40.4	0.0	0.0	0.0	0.0	0.0
7	DN	Refurbishment Project Office [3]	73815	F&IP	Sep-11	Jan-16	99.9	0.0	99.9	0.0	7.6	0.0	0.0	0.0	0.0	0.0
8	DN	Electrical Power Distribution System [3]	73821	F&IP	Nov-10	Oct-15	20.8	0.0	16.9	20.8	2.4	0.0	0.0	0.0	0.0	0.0
9	DN	Third Emergency Power Generator [4]	73360	SIO	Apr-12	Oct-16	120.4	0.0	77.2	120.4	105.3	0.0	0.0	0.0	0.0	0.0
10	DN	Containment Filtered Venting System [4]	73365	SIO	Aug-13	Aug-16	80.3	0.0	80.6	0.0	80.1	0.5	0.0	0.0	0.0	0.0
11		**Subtotal**					5,793.5				327.4	366.4	0.0	0.0	4,799.8	0.4
		COMPLETED PROJECTS FROM EB-2013-0321														
12		No projects in this category					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13		**Subtotal**					0.0				0.0	0.0	0.0	0.0	0.0	0.0
		PROJECTS NOT IN EB-2013-0321														
14		No projects in this category					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15		**Subtotal**					0.0				0.0	0.0	0.0	0.0	0.0	0.0
16		**Total - Projects ≥ $20M Total Project Cost**									327.4	366.4	0.0	0.0	4,799.8	0.4

$335.3 million

Notes:
1 Projects with expenditures during Test Period OR In-Service Amounts in Bridge or Test Period.
2 In-Service forecasts reflect RQE.
3 For F&IP, Total Project Cost and release information reflect approved Business Case Summary.
4 For SIO, Total Project Cost and release information reflect approved Gate Progression Form or Change Control Form.

- Mischaracterized the nature of these estimates by assuming anything provided by a contractor was at a very high level of maturity (Class 3/2) when such estimates were based on conceptual (at best) engineering, meaning these estimates could not have been better than Class 5 (-50% to +100%) in nature;
- Failed to establish accountability standards for the contractors;
- Failed to identify or mitigate known risks;
- Did not effectively react to problems when they materialized and accurately and timely report the extent of cost overruns, schedule delays and scope increases to senior management;
- The P&M Team did not seek to lock down the scope at start of this work and allowed the "customer" – Operations and Maintenance – to make significant changes to the design that were not properly understood, quantified or captured in subsequent reports to senior management; and
- The ESMSA contractors contributed to the problem by not transparently reporting or timely identifying how these projects were evolving and failing to provide any reliable metrics—cost, schedule or otherwise – that informed OPG of these brewing problems.

2. Indicative Projects - D2O Storage and Auxiliary Heat

In our analysis, BMcD/Modus examined five separate projects in detail, and each exhibited some or all of the management issues to some extent. Attachment C is a brief summary of each of these projects' cost overruns.

The management failures we observed were most evident and acute with the D2O Storage and AHS projects. These projects were the "pilot" EPC projects for the ESMSA contractors—[redacted] In both cases, P&M sought the Board's full funding approval at a point when very little design was done, only to have to later seek additional funds from the Board once design had matured.

a. The Flawed Bidding/Estimating Process

P&M's management failures can be seen throughout the planning and execution phase of the project. Notable from OPG's initial negotiation and acceptance of bids for this work is P&M's mischaracterization of the vendors' estimates in the approved Business Case Summaries ("BCS"). In August 2011, OPG produced a BCS for D2O Storage that estimated its cost at $210.6M, [redacted]. At the project's next gate in June 2012, the estimated cost had dropped from $210M to $108M. However, BMcD/Modus could not find any attempt by P&M to rationalize or otherwise explain how the cost estimate for this building was cut virtually in half from one approval gate to the next. Moreover, the estimate for design and construction was $52.2M, which P&M characterized as a "Class 2 Estimate" despite the fact that at the time of the estimate, Black & McDonald had little experience with this type of construction and had performed no engineering or scope definition. Thus, this estimate was more likely a Class 5 Estimate. In retrospect, it is likely that the initial $210M estimate was more accurate; however, it is certainly clear that the approved $108M estimate should not have had any greater accuracy attributed to it, since it was not based on a significantly greater level of project maturity. Likewise, the AHS BCS was termed a "Class 3" Estimate, though it was similarly immature.

This estimate classification drove P&M to vastly underestimate the amount of contingency associated with each package. There is no evidence that P&M engaged in the type of vetting of the estimates that we would expect on projects of these size and importance. From interviews with the current P&M staff and the contractors, it appears that these initial BCS estimates were poorly characterized as part of a deliberate management strategy directed by the former VP of P&M. P&M's managers told us that the contractors were challenged to reduce their bid prices and remove all contingencies for unknowns, despite the extreme immaturity of project definition underlying their respective bids. As

(a) D2O Storage

The D2O Storage project's cost estimate and schedule remain very much in flux at this time. Since our 2Q 2014 Report, despite the ongoing efforts of Black & McDonald, Faithful + Gould (the DR Project's estimating team) and the P&M team, the project estimate for D2O Storage has continued to increase, adding approximately 25% in estimated cost since that report. Importantly, the estimate was not deemed by OPG management to be of sufficient quality for presentation to the NOC for the upcoming Board meeting. Approximately half of the D2O Storage estimate has not been vetted by OPG at this time because Black & McDonald had not provided the portions of its estimate related to fixed-price contract work by its third tier construction and first tier engineering subcontractors. Moreover, the status of the value engineering and constructability reviews P&M requested Black & McDonald to perform is uncertain. As such, the issues with the accuracy of the current cost estimate call into question whether Black & McDonald and its subcontractors have a reliable detailed schedule for the work, as the estimate and schedule go hand-in-hand.

The current target date in the DR Project's schedule for D2O Storage Available For Service date is August 31, 2016, which is 110 days late in meeting the DR Project's optimal schedule date of April 15, 2016. This August schedule target assumes an acceleration plan that shaves 4 ½ months off a current projected completion of January 18, 2017 that was derived without acceleration. Black & McDonald's acceleration plan embeds productivity and performance risk, and even if successful the resultant August 31, 2016 date may prove to be a challenge for OPG to support Unit 2's Breaker Open of October 15, 2016.

There is also continued risk in the D2O Storage schedule until final detailed engineering is completed and all of the potential value engineering and design simplification measures are finalized. Black & McDonald's design subcontractor RCM Technologies ("RCMT") reports that its work is over 80% complete, though this estimate is suspect in that there are more than 20% of the design packages outstanding and RCMT projects a design completion date of February 19, 2015. The DR Team has examined the earning rules used and determined that RCMT's calculation of earned value was not aligned with OPG's; this alignment is in process. Any changes to the building could further delay engineering such that it may not be possible to simplify the design and still meet schedule. RCMT has also stated that it is out of funding for engineering under the current release.

The D2O Storage schedule suffers from the same transparency issues from Black & McDonald's subcontractors as the cost estimate. Black & McDonald's subcontractor Ellis Don's schedule for the concrete and civil construction cannot be verified against its cost estimates because its sub-contractors' pricing is based on fixed-prices that Black & McDonald has thus far refused to provide to OPG. Also, procurement activities need to be scheduled and verified with some level of confidence that currently cannot be associated with RCMT's efforts.

In our experience, a successful acceleration plan of this magnitude must be well-planned and coordinated, and the schedule for the work needs to be reliable with full buy-in from all needed stakeholders and contractors. There are currently a number of challenges with the D2O Storage project that will bear on the confidence in the schedule, regardless of which completion date becomes the target. As of this writing, P&M's new leadership is considering the next steps for D2O Storage.

(b) Auxiliary Heat

The current March 26, 2015 Available For Service date for AHS is virtually at the start of the Vacuum Building Outage ("VBO"). As with the D2O Storage above, the contractor (ES Fox) has incorporated acceleration in the form of a two shift schedule for piping and electrical work beginning in August of 2014. This acceleration of the work provides no float or cushion for the VBO, which is a critical milestone. ES Fox recognizes that this schedule is very tight and has little room for failure or delay. ES Fox has raised concerns with the pace of OPG's design approvals and final acceptance of vendor drawings, which could further risk the timeliness of the schedule. OPG has embedded Resident Engineers with the Hatch/Sargent & Lundy ("H/SL") design team to respond to issues through the completion of AHS engineering.

We also meet almost daily with members of senior management, Engineering and the project teams for RFR and BOP to monitor Project cost and schedule status, engineering progress and project planning for these high-risk activities. Additionally, we continue to meet monthly with the Refurbishment Project Executive Team ("RPET") and weekly with the DR Team's Management Systems Oversight group to discuss the recommendations we have made in these Reports to NOC in order to engage in discussions of appropriate OPG management actions. The DR Team continues to provide its cooperation and transparency to our oversight efforts.

III. Campus Plan Update

A. Overview

The Campus Plan Projects continue to have schedule and cost risk (particularly D2O Storage). Scope definition of smaller Campus projects may continue to reduce management reserve and contingency. Over the last year, the Campus Plan Projects, excluding D2O Storage Facility, have incurred approximately 20% cost growth overall. While these projects are generally smaller in size and, in aggregate, represent ~5% of the program cost, their success remains important to Refurbishment. In addition to D2O Storage and AHS, some Campus Plan Projects that have received partial funding are showing signs of scope creep and schedule issues; OPG is actively monitoring and mitigating these issues to the extent possible and has increased the effectiveness of its regular meetings with the ESMSA contractors and associated metrics that are intended to root out problems before they increase in in severity.

The D2O Storage Facility remains the principal focus for P&M due to its size, growth, lack of predictability and importance to Refurbishment. OPG is currently estimating the cost of the D20 Storage Facility to be $373M, an increase of $263M from the full funding release request in May, 2013. The on-going performance issues with the principal contractor, Black & McDonald have diverted management attention from the other projects. While the work needed to replace Black & McDonald and mitigate the impacts will require an intense effort by P&M, the change in course for D2O Storage Facility should have an overall positive impact on P&M and the F&IP work.

B. Major Campus Plan Projects

1. D2O Storage Facility

On October 16, 2015, OPG terminated Black & McDonald that its purchase order for the D2O Storage Facility. This termination was limited to D2O Storage Facility; Black & McDonald is expected to continue with its remaining purchase orders for both P&M and Refurbishment, though OPG had previously announced its intentions to restrict or reassign much of that work to other ESMSA contractors. Under the provisions of the ESMSA, OPG has also provided a written notice to Ellis Don that OPG will be assuming direct control of its subcontract to continue work in the field on the D2O project. For the time being, the work will proceed on site according to the current schedule while the DR Team considers the next step.

In light of the termination, OPG will need to reassign or rebid the work to another contractor while it develops a mitigation plan capable of draining the water from Unit 2 with minimal impact to Refurbishment. OPG will need to devote significant attention to vetting the new plan so that it is developed with sufficient quality to meet the needs of Refurbishment. The DR Team has assigned a team consisting of appropriate Engineering and Operations & Maintenance personnel to develop options for an alternative approach that will allow the DR Project to meet the breaker-open date for Unit 2 in the event that D2O Storage is not complete. Such a solution should be properly planned and made ready for execution with a mature a Class 2 level cost and schedule on the assumption that it could, at some point, be the only alternative for storing water from Unit 2.

OPG is currently considering its available options and is developing a revised business case for proceeding. We recommend that OPG consider the following options in its business case:

- *Reassign the D2O work to one of the other ESMSA contractors (assuming there is another ESMSA in place with capacity to handle the work) through either direct award or a secondary compete process.* The new ESMSA

1. Vendor Performance Issues

We have ongoing concerns, shared by the DR Team, regarding ES Fox's bandwidth to support the volume of the upcoming work on the DR Project. These issues are acute at this time as ES Fox has a number of "in-flight" P&M projects while also being required to support planning efforts for multiple Refurbishment projects. Our comments regarding ES Fox's scheduling and cost estimating capability have been discussed in prior reports, [redacted]

In addition, ES Fox must prepare approximately 45 separate project estimates for BOP and Shut-Down/Lay-up Refurbishment projects prior to RQE and oversee the final development of the associated detailed engineering packages from its engineering subcontractors. The Refurbishment BOP and Shut-Down/Lay-up directors have tasked ES Fox with developing estimates and schedule pilots that will be used as a template for the remaining estimates; these pilot estimates and schedules are under review.

The OPG executive team has escalated these issues to ES Fox's senior management, from whom OPG has received assurances that ES Fox intends to strengthen its capability by adding core team members for project management, project controls and other needed positions. ES Fox's actions bear watching, as their ability to complete these critical Campus Plan Projects while simultaneously supporting the planning of BOP and Shut-Down/Lay-up work for Refurbishment is a growing risk to the Project. The DR Team should continue its efforts to evaluate its needs from ES Fox and continue to hold them accountable for making necessary changes to support this work, and consider if there is an opportunity to balance work amongst the other ESMSA contractors.

2. Major Campus Plan Projects

D2O Storage Facility

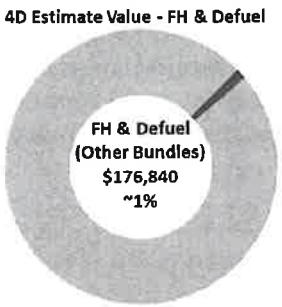
The DR Team has prepared a Superseding Business Case Summary ("BCS") recommending an additional release of $270.9M, including [redacted] of contingency, with a projected total cost of $381.1M. The BCS examined four alternatives, including slowing down construction at different points and abandoning D20 Storage entirely. The BCS also considered and established the basis for an alternative plan to draining water from Unit 2 in the event that D20 Storage construction is further delayed, and the DR Team has established trigger dates for proceeding with the alternate plan in sufficient time to procure temporary tanks and other material if needed. BMcD/Modus believes the BCS has appropriately considered the reasonable options at this time and provides a basis for justifying the decision to proceed with the best available option, completing D20 Storage based on the original design in time for Refurbishment.

With $123.1M spent to date, the remaining cost to complete is estimated at $258M, of which approximately $140M is estimated for the new completion contract. As of this time, the award for the MEP completion of D20 Storage had not been made, as the OPG team is considering which of the ESMSA contractors should be awarded the completion of the work. In any event, the contract needs to be awarded and progressed by mid-March so that the selected contractor can begin piping prefabrication, procurement and further development of its execution schedule. The P&M team has committed to following Refurbishment's earned value and project controls processes for D20 Storage, which will provide a good proving ground for these processes for Refurbishment as well as significantly improved controls over P&M's past practices. In addition, P&M has added management resources and has established weekly progress meetings to focus on P&M's management of the work.

Based on the current D20 Storage schedule, the revised plan appears achievable, though with all of the issues to date,

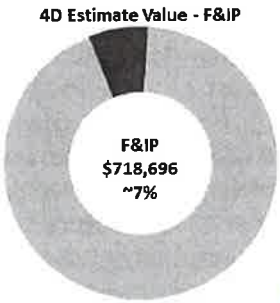
development of CWPs. The DR Team has placed a goal of having BOP projects proceed to their Gate 3 between late November 2015 and January 2016. To do so, ES Fox will need to complete the detailed level 3 execution schedules, Class 2/3 estimates and Construction Work Packages to support these gates. To meet these goals, the BOP team has set interim milestone dates with ES Fox for these deliverables which will be regularly pulsed by the team.

Fuel Handling/Defueling:



The DR Team has received and accepted vendor Class 3 level estimates for RQE based on completed engineering from GE/Hitachi. Cold commissioning is ongoing for Fuel Handling system modifications, and while performance indicators had been lagging, recent progress has dramatically improved overall schedule performance. The recovery plan has also allowed the team to advance plans for testing and training. These recent improvements should allow for a better understanding of the critical path project durations and performance risks

Campus Plan Projects:



The overall performance of the most significant Campus Plan Projects – D20 Storage, Auxiliary Heat System ("AHS") Building, and Emergency Power Generator 3 ("EPG3") - has continued to be impacted by ongoing issues with poor initial estimates and scope definition, site conditions, contractor performance and OPG oversight.

- ***D20 Storage*** – OPG issued a purchase order to SNC/Aecon on July 31, 2015 that covers the mechanical, electrical and civil/structural work from grade. SNC/Aecon has provided an estimate and schedule for the work that still needs continued development. SNC/Aecon initially submitted its cost and schedule proposal on April 9, 2015 though it was rejected by OPG due to a number of unacceptable commercial and scope exclusions. SNC/Aecon revised its submission on July 8, 2015 including an estimate proposal of $148M, an increase of $8M from the prior submission, with a Class 3 bandwidth. OPG's estimating team issued approximately one hundred comments to which SNC/Aecon agreed to respond; to date, these have not been fully addressed. While it was necessary for P&M to release this work to SNC/Aecon, it is important SNC/Aecon complete and fully submit its estimate for RQE so that OPG can properly assess risks of performance and potential costs. The Refurbishment Estimating team is supporting P&M in completing the vetting of the details of SNC/Aecon's estimate to determine whether it is of sufficient quality to meet contractual requirements and allow for OPG's assessment of risk and contingency. This is needed to support RQE.

Ellis Don continues to perform the underground civil work, including foundations, dyke walls and closure slab at grade. Currently, the schedule (dated August 4) shows Ellis Don is 57 work days (82 calendar days) behind in meeting the key milestone for setting of the D20 tanks. On August 6, the D20 Storage team identified a partial recovery of approximately 15 days (to January 13th) of this milestone through resequencing of the work. However, at Ellis Don's current pace (SPI is 0.58), it is likely that these dates will continue to slip. If this work cannot be recovered, it will significantly compress SNC/Aecon's work and could impact Unit 2's need to use the D20 Storage tanks for moderator and primary heat transport drain after breaker open. OPG needs an execution schedule for D20 Storage that can be executed by the performing contractors based on the current understanding of the work, realistic projections based on field productivity to date, and which accounts for the limiting factors in the construction of the building.

We have recommended that P&M assess these risks using SNC/Aecon's estimate and schedule and revisit the business case to confirm whether the path chosen for execution is the most prudent course, and whether the team should revisit options for temporary storage of Unit 2's heavy water. It is notable that SNC/Aecon

conceptual design and associated cost estimates that did not match the complex requirements of the project needs. While cited as a Class 2 estimate, this was not the case. For example, the conceptual design did not include the amount of piping, shielding requirements and vapour recovery systems required to meet operational and environmental requirements in the final design. The current project budget of $381.1M as set out in the superseding BCS dated March 2015 reflects required project scope and costs as the design now properly incorporates the engineering, design and safety requirements to address the need and complexity of the project. Therefore, the superseding BCS (see Attachment 1, Tab 1) provides the relevant and appropriate basis for evaluating the costs associated with the scope of work that is required for the Heavy Water Facility project.

The changes in the forecasted project costs are primarily associated with progressing from conceptual design requirements to detailed design requirements to ensure the proper design and functionality of the project. Design concerns were raised by OPG and independent oversight at the initial stage of the project, with work not having progressed beyond site preparation. OPG took definitive steps to become more actively involved in the facility's detailed design to ensure the proper scope. This included co-locating OPG engineering staff with the contractor's design team.

Ultimately, OPG determined that the contractor's performance on this project was unsatisfactory and in October 2014, terminated the Heavy Water Facility purchase order for default. OPG assumed the role of general contractor for an interim period while it secured a new contractor. The SNC/AECON JV has now been awarded the contract to complete the project.

The changes in project cost are design related to ensure a scope that matches the need and do not reflect any significant reworking or reconstruction of facilities. The increased project budget reflects true project costs as the design was further developed.

Design changes included the following:

d. The Gate Process and Failure to Report Cost and Schedule Increases to Senior Management

BMcD/Modus next explored the relative effectiveness of the gate process for this work, and found that while the process in concept is a good one, it suffers from problems in execution. The BCS documents for D2O Storage and AHS were inconsistent in presentation of key information on cost, risk and scope. As these projects progressed, P&M's management failed to provide visibility to OPG management of the extent or nature of project cost increases. Most notably, P&M failed to update its project reports during the design phase to reflect cost increases due to scope changes in the projects.

AHS provides a critical example. On November 12, 2012, P&M presented its Gate 3A package for approval and full funding release (except for a small portion of costs to be approved in 2014). The P&M Team's gate presentation characterized the AHS cost estimate as a Class 3 estimate in the amount of $45.6 M. P&M included [redacted] of contingency in the $45.6M estimate, of which [redacted] was identified as having a 100% chance of occurrence. P&M expressed an "85% confidence level" in this cost estimate and assessed there were [redacted] days of schedule contingency in the estimate—despite the fact that the full scope of the project was not known at that time because detailed engineering had not started. The option of building a new AHS was preferred over seven alternatives, based primarily on the projected cost. At the time of this gate, the project had spent $1.46M.

Between this gate and January 2014, ES Fox engaged in the design of the AHS, scope changes caused the cost to increase from the initial $45.6M estimate to $79.9M. This cost increase is largely attributable to two causes: (1) remediation of contaminated soil that as of the time of bid was known by both OPG and the contractor to be of poor quality; and, (2) prescriptive design requirements that served to make a stock steam boiler design follow nuclear Engineering Change Control ("ECC") processes, which caused an increase in the size, complexity and nature of the work. Moreover, these design requirements and the overall length of the design phase, coupled with the soil issues, has frittered away virtually every day of float.

The fact this project had so substantially changed from the original BCS was not accurately or timely reported to management. The failure of the gate process was that the Gate Review Board members did not provide adequate oversight in ensuring that the AHS project team had a reliable estimate, schedule, and well-defined scope prior to approving the gate and recommending a funding release. As of January 2014, P&M had already expended nearly $20M, or more than half the approved budget excluding contingency, even though the design was not complete and no construction had begun. However, during this entire time, P&M's estimate at completion ("EAC") in all of the DR Project's and Campus Plan reports ***never varied*** from the approved BCS amount. Moreover, the DR Project's Program Status Report for March 2014 showed the AHS at 49% spent with a CPI of 1.10 and an SPI of 1.0, clearly not an accurate representation of the Project's status. Part of this failure was based upon some of the P&M project managers' mistaken belief that the reported EAC amounts should not be changed until additional funds had been approved for the projects. This lack of accurate reporting has deprived senior management and the Board the option of revisiting the original BCS analysis in order to determine if building a new AHS facility continues to be the preferred option—and if not, change course. This is particularly true in light of the fact that as of November 2012, three of the competing options to building AHS were priced at less than $50 M.

D2O Storage provides a very similar example at a much higher overall cost. The cost variance progression from D2O Storage began with an original approved BCS of $110M, based upon estimated contractor costs of approximately $77.8 Million. The ES Fox team and design solution were both preferred but Black & McDonald was chosen entirely because its price was $30M less even before P&M further drove Black & McDonald's estimate down.

D2O Storage's engineering effort was originally scheduled for 11 months, and was supposed to be completed by July 2013. However, even today, engineering is not complete and is projecting to extend to a total duration of 29 months. The P&M team provided sporadic updates to the design milestones as they continued to be missed but failed to convey the potential consequence. In August 2013, P&M reported that CNO Milestone 73472M0015, "D2O Modifications –

contractor would have to quickly mobilize, take possession of all purchased materials, plan and schedule the work, subcontract off-site prefabrication and other work, and perform on an accelerated basis in an attempt to complete the building prior to Unit 2's breaker open (or as soon as possible thereafter). The alternative approach will be used only as a mitigation strategy so as not to delay breaker open; or

- *Issue an RFP to qualified contractors that assumes an aggressive schedule in order to complete the work as quickly as possible.* Again, this option would require quick mobilization and acceleration costs. Bid evaluation will be based upon rate sheets, overhead, supervision costs, fees and potentially the best construction plan, but the bid period will be short so that a full schedule and estimate of the work cannot be developed and evaluated as a part of the bid. This plan would allow negotiation of a project-specific contract that would incorporate appropriate milestones for developing cost and schedule as well as incentives and disincentives for contractor performance.

- *Issue an RFP to qualified contractors assuming that the completion milestone will be extended for a reasonable amount of time allowing for a true "competitive bid" process based upon completed engineering.* In this scenario, OPG would implement the mitigation plan to drain the water and complete engineering and some of the current excavation work. Once engineering is complete, the project can then be re-bid on a competitive basis, seeking both a realistic schedule and pricing for the Project. This would also give OPG time to re-examine the needs for the D2O Storage Facility and decide whether the design properly addresses that need, and whether the cost is justified based upon a sound business case. This scenario may also allow OPG to achieve some of the value engineering solutions for reducing the D2O Storage Facility scope in a less compressed time frame.

While the design work is largely complete, the first and second options will require quick action for another contractor to assume the work, develop a cost estimate and schedule and re-plan the work effort to minimize lost time. Such a plan will likely include added costs for acceleration, and even with those added costs, the new contractor may not be able to complete in time to support breaker open. Moreover, whichever contractor takes on the work is likely to include a premium in its price due to these circumstances. The third scenario could provide OPG the opportunity to establish the true cost of the project (whether or not the design changes) in a competitive bid environment, and to show that the cost increases are reasonable and based upon increased scope. It may also enable OPG to seek a different commercial arrangement for its construction. The third option would have the disadvantage of OPG having to incur added carrying costs, which could actually make this option cost prohibitive, but it should be evaluated as a part of the business case.

Under any scenario, completing the D2O Storage Facility to support the start of the Unit 2 Refurbishment has a considerable amount of risk and the option OPG chooses to procure the completion of the building needs to fully account for those risks. Thus, having the alternative solution for draining the water from Unit 2 should be assumed for any modeled scenario, and we would recommend management establish a well-defined decision point appropriately in advance that specifies the direction the team will take if ongoing construction work on D2O Storage Facility cannot meet the needs of Unit 2's schedule. That plan needs to consider long lead items, approvals needed from external stakeholders and impact on operations, at a minimum OPG is reviewing its options at this time, and is preparing a revised business case that should consider these and any other reasonable scenarios for the Board of Directors' review.

2. Auxiliary Heat

The Auxiliary Heat System ("AHS") originally was scheduled to be in service prior to the start of the VBO. The current schedule for commissioning the new Auxiliary Boilers shows an in service date of May 25, 2015, nine weeks beyond the original target. P&M management has pivoted its focus on the likelihood that the new AHS will not be available for the start of VBO. The existing boilers will remain in place until the new AHS is available for service, which will meet OPG's needs for VBO. The remaining issues are with the AHS's cost and schedule predictability. As noted, ES Fox has also agreed to deliver to OPG its full estimate for AHS and is working with OPG to further refine its schedule. ES Fox is already working two shifts on the critical AHS work in an attempt to recover as much time as possible. The P&M team is evaluating ways to shorten commissioning and start-up and staging release dates for the equipment.

completion of the building will require close attention by the DR Team. Once the contract award is made, we recommend the P&M team: (1) re-evaluate the project risks based on the revised execution model; (2) fully vet the schedule and earned value set-up; (3) apply the project controls strategy to the completion of the foundation work.

Auxiliary Heat

As noted, the work on the Auxiliary Heat System Building ("AHS") was impacted by ES Fox's safety stand-down following two separate safety incidents. AHS is also impacted by the change to the Vacuum Building Outage ("VBO"). AHS was initially planned to be commissioned before the VBO in the spring of 2015, though its completion was later relaxed because it was determined that the building was not needed for the spring VBO. However, AHS now must be available for service for VBO in the fall. The AHS schedule had slipped by 2 months to October 2015 due to the Steam and Condensate tie-in window changing. This completion date is too close to the start of VBO, and will require ES Fox to resequence its work to recover this slippage. OPG is working with ES Fox to improve its schedule in consideration of the shift in the VBO date.

The current EAC of $85.14M is being challenged by ES Fox, who has over $6M in change orders ($5M for engineering) that it has submitted to OPG. Construction was reported by P&M to be 45% complete, which needs to be verified, in particular because ES Fox has spent 78% of its EPC contract value through February 1, 2015 and ES Fox's SPI continues to deteriorate. P&M needs to validate these figures, and needs to ensure that ES Fox is motivated to expend the needed direct field labour to complete this project.

AHS also represents the first major Campus Plan Project to be commissioned with cooperation from Operations & Maintenance. We would advise the P&M team insist ES Fox provide as much float as possible before VBO to allow for any slips in commissioning.

Emergency Power Generator 3

EPG 3's current performance trends are also a concern, and the Project Team is reporting the planned September 2015 in-service date is at risk by as much as 2 months. ES Fox's performance indicators continue to deteriorate and the Project's EAC is $96M, an increase of $8M since 4d. Engineering completion has been delayed to May 2015 due to vendors' performance challenges. The P&M project team was readying EPG 3 for its final Gate 3, though these trends and ES Fox's additional cost submissions and delayed schedule development have pushed this gate meeting. The Project Team is also carrying the commissioning of EPG 3 as a significant risk due to the complexity of commissioning and configuration of this equipment.

P&M's management has requested a full recovery plan from ES Fox, and the SVP of Projects has requested a focused, weekly update to examine ES Fox's performance. Given the short timeline to complete this SIO project, ES Fox will need to increase its effort and improve its performance.

III. Other Focus Areas

A. Corporate Support

BMcD/Modus remains encouraged by the ongoing efforts by OPG's corporate units to support the DR Project. Among the Project Team's recent issues is highlighting its software needs for IT to implement needed changes, particularly for change project controls systems needed for project. Large capital projects often struggle using enterprise level business systems to support project needs, and recognition of the shortcomings of the current systems is timely. A similar approach should be pursued with other corporate policies; as previously discussed, tailoring hiring and talent retention processes for short-

August 2015

currently classifies its estimate at Class 3, as the business case was premised on a Class 2 estimate, meaning that additional contingency may be needed to cover the risks. P&M is also pursuing options with SNC/Aecon to further improve the schedule and sequence of the work. In any event, this analysis must proceed so that the risks of performance are adequately captured and monetized in RQE.

- ***AHS*** – The AHS project, which has been subject to schedule delays and cost increases, is nearing completion. The current schedule shows the work is 92% complete and construction testing of the systems has begun. The target for completion is October 2015 based on a full understanding of the commissioning effort. OPG and ES Fox have executed a fixed price amendment to cover the outstanding costs that had been pending for several months. The current projected final cost is $99.5M, which has required a contingency draw of $15M over the approved $84.52M budget in 4d. AHS has provided multiple lessons learned that Refurbishment is taking into account in planning of BOP and Shut-Down/Lay-up work with ES Fox.

- ***EPG 3*** – This project must be completed prior to Unit 2's breaker open. Construction has been impacted by issues with plant tie-ins and unforeseen underground conditions. Engineering of modifications to the EPG unit are complete, and ES Fox has provided OPG with an estimate at completion of $115M (increased from $88M in 4d). The Refurbishment Estimating team needs to fully vet the details of the estimate to determine whether it is of sufficient quality and represents a sound plan. In addition, the schedule for construction requires additional vetting to confirm the constructability and sequence of ES Fox's plan. These details need to be addressed before the project advances to its upcoming Gate 3.

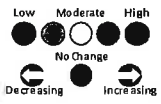
In prior reports, we have commented extensively on the P&M team's structure and capabilities for managing the work. P&M had previously committed to making improvements in areas of project management, project controls and risk management through additional training and adopting Refurbishment processes, where necessary. These improvements need to be accelerated to properly manage the remaining Campus Plan Projects to completion within the RQE control budget. In addition, we have raised the risk of ESMSA contractors' performance deficiencies. The step-up in collaboration between the Refurbishment team and the ESMSA contractors has resulted in higher quality engineering packages and project estimates. The vetting effort described above with SNC/Aecon's D20 Storage proposal provides an example of the benefits that P&M has achieved. These same efforts need to be applied to all remaining Campus Plan Projects, as necessary, to reduce risk of remaining performance and attempt to properly characterize the risks of these Projects to the Refurbishment program.

III. Areas of Focus - RQE Quality

Estimate Characterization

The process of validating and vetting EPC cost estimates for the Project's bundles has followed the approved DR Project RQE Cost Estimate Plan. The vendors presented the cost estimate packages to the OPG Project team in a multi-stage progressive review process for comments and disposition. Among the issues covered at each review stage were scope, COMS, schedule, identification of key cost drivers, estimate basis, benchmark ratios, exclusions and assumptions, as well as cost challenges on a number of issues, such as vendor PMT, indirect costs and productivity factors. Once the EPC vendor completed the comments and disposition phases, and a final revised estimate was received, OPG's estimating team then loaded the estimates into the US Cost estimating platform for analysis.

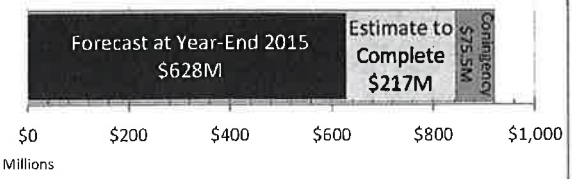
Once loaded into OPG's US Cost database, OPG's estimating team then vetted and validated the estimate data to determine if the estimate was accurate, reasonable and competitive to the desired classification; as well as, identified any gaps in the documentation or methodology that may negatively impact the quality of the final estimate. The team then performed a technical review of the estimate from a scope point of view and proposed an AACE classification for further review. The process is documented with review checklists. Another member of the estimating team performed



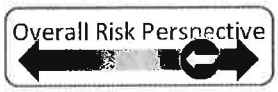
CAMPUS PLAN PROJECTS (CP – F&IP AND SIO)

CP – F&IP and SIO Project Summary	
Control Budget:	$920,079,000
RQE Base Cost:	$844,621,000
Estimate to Complete:	$216,713,000
Project Contingency (as a Percent of ETC):	$41,525,000 (19%)
(Project + Program Allocated Cont.):	$75,458,000 (35%)
Estimate Class:	Not Applicable
Percent of RQE:	8%

Control Budget
$920M



Risk Perspective



1. Budget Status

There are six active Campus Plan Projects in execution at this time with the Refurbishment Project Office ("RPO"), the RFR Island Support Annex ("RFRISA") and Replacement of Buried ESW Piping approaching completion. There are two other pre-requisite projects, the Auxiliary Heat System ("AHS") which for budgetary purposes was reclassified as a Station project though P&M is still managing the work. The costs for AHS are no longer carried in RQE. The other pre-requisite project, the Refurbishment Waste Processing Facility ("RWPB") is being performed by SNC/Aecon under the RFR Definition Phase contract and is not part of P&M's reporting.

We have noted in past reports that while the remaining dollars involved in the Campus Plan Projects do not necessarily have a significant monetary impact to RQE, certain of the projects, most notably D20 Storage and EPG 3, remain a risk to breaker open of Unit 2. These projects' completion dates have shifted over time and further delays could result in drawing attention away from the Readiness to Execute plan. Overall, the entire portfolio of Campus Plan Projects experienced $76.3M in base cost growth from 4d to RQE, an increase of 9%, which resulted in contingency drawdowns from the allocated budget amount set in 4d. P&M is currently forecasting an Estimate to Complete ("ETC") for all remaining Campus Plan and SIO work of $216,713,000.

2. Contingency

Based on the history of these projects, the velocity of change and the volume of remaining work, the $75.5 million in remaining contingency needs to be closely tracked to ensure it is enough to cover any remaining cost issues with completing these projects. In particular, D20 and EPG3 pose the greatest risk to the remaining Campus Plan Contingency, and EPG 3's final cost estimate has not been fully vetted and approved. P&M's change control process needs to be monitored so that the use of contingency is readily identified and so there are sufficient funds going forward. In Section III below we discuss the status of these projects and describe some of the risks that could cause the base costs for these projects to increase.

FUNCTIONS

With the exception of Operations & Maintenance, the remaining functional groups that compose the DR Team jumped in size from 4d to RQE. The non-Operations & Maintenance groups' cost estimates increased in aggregate from $1.28B (2015$) to $1.53B, an increase of 20%. The largest gains were for the Execution Organization (48%), Contract Management (38%) and Managed Systems Oversight (42%). Operations & Maintenance's budget decreased by from $1.1B (2015$) at 4d to $0.81B for RQE, a reduction of 27%. This reduction was due primarily to identification and removal from the DR Project of non-Refurbishment Operations & Maintenance costs.

The DR Team has high confidence in the extent of the estimates it has prepared for RQE and are all-inclusive of what could reasonably be identified for staffing at this time. However, the pace of the proposed ramp-up of the DR Team's staff is aggressive and will be very difficult to meet. In order to meet the plan, the DR Team would have to increase from 770 to

of any impact can be properly documented and managed. [redacted] SNC/Aecon intends to do so once it has secured agreements with its major structural, civil and HVAC subcontractors. SNC/Aecon has committed to reporting key subcontractor status via earned and actual work hours against its plan, which should provide P&M with enough information to track this key work.

The current SNC/Aecon schedule is based on the D2O project meeting an interim deadline of June 28, 2016 to accept water from Unit 2 so that there is confidence that Refurbishment of Unit 2 can proceed. This deadline was initially set about 1 year ago when the DR Team reviewed the need for a contingency plan for D20 Storage in the event the building could not be completed. We have recommended that P&M and Refurbishment re-examine this milestone if it is able to implement one of the alternatives it is currently reviewing for draining primary heat transport and moderator water from Unit 2. If an effective mitigation strategy can be implemented, it could allow deceleration of some of the work which could potentially reduce the overall risk of construction. However, such a deceleration should only occur if it is supported by objective progress data from field progress that substantially improves the confidence of all concerned that D2O Storage Facility will be available for Refurbishment of Unit 2.

B. EPG 3

OPG has committed to placing EPG 3 in service prior to Unit 2's breaker open. The civil construction is currently approximately 20% complete, and ES Fox intends to set the EPG unit by the end of November. Construction has previously been impacted by issues with plant tie-ins and unforeseen underground conditions. In its Project Status Report issued October 29, 2015, P&M reports that "Corporate milestone "Generator In Place" – Nov 30, 2015 currently at risk." While there is a recovery schedule in place, the Project Status Report currently shows that the Turnover/Available For Service milestone is not forecasted to occur until August 5, 2016 (323 days late), only two months in advance of breaker open. Furthermore, it should be noted that neither the additional forecasted costs ($21.3M over the approved amount of $88.2M) nor the recovery schedule have gone through a gate for final approval. The gate approval was originally scheduled for September 11, 2015, but that has been delayed until 4Q 2015. It is critical for OPG and ES Fox to agree on a schedule that is doable and predictable as soon as possible.

In its Project Status Report, P&M reports that "Engineering holds remain on a number of packages to incorporate design input from LLM Vendors. Holds to be resolved by Dec 2015." These engineering issues should not impact the civil work, though some involve changes to allow the stock generator to meet OPG operational requirements which could impact the installation or in-service date of the EPG unit if they are not resolved in time. The VP of Engineering and Sargent & Lundy have established a process for working through these issues and bringing more timely visibility to engineering issues as they arise on ESMSA (Campus Plan, BOP and Shut-Down/Lay-up) projects.

P&M also identified EPG 3's commissioning as a risk. "This is a first time evolution for these modifications and there is limited commissioning experience with this type of equipment. The risk is that the commissioning of this new system may take longer and be more challenging than anticipated/estimated resulting in numerous work interruptions/clarifications and extension to the schedule or missing AFS (OPEX from Pickering Temporary Emergency Power System)." To mitigate this risk, the DR Team has assigned a dedicated manager to lead the commissioning effort, though the schedule should accommodate the time needed for commissioning with these risks in mind.

P&M's Program Status Report dated October 23, 2015 showed the forecast as $115M, and noted that, "the forecast is expected to increase by an additional $5-10M. The increase is a result of additional costs to recover schedule delays that occurred during excavation and fuel line relocation, design changes based on newly available equipment information, and additional resources and time allotted for commissioning. This cost increase can be accommodated within the available contingency." P&M further noted in the October 27th Project Status Report that, "Significant costs increases are being addressed with contractor. SCRs in place," and "A new gate package will be prepared to identify the new EAC and schedule completion," which P&M anticipates having in 4Q 2015. The gate approval was originally scheduled for September 11, 2015, but that has been delayed until 4Q 2015. It is critical for OPG and ES Fox to agree on a cost estimate and schedule that is doable and predictable as soon as possible.

management team and a full reforecast of the cost and schedule before its next gate so that the basis for the changes in scope can be identified and challenged, and the planning and execution sequence can be confirmed. In addition, to the extent the contractor has provided monetized risk items, these need to be properly accounted in the project's request for contingency at the next gate.

(d) Containment Filter Venting System

The Containment Filter Venting System is another SIO project that addresses a potential need to release steam from containment under extreme conditions where the station would be subjected to a complete loss of power. The scope of the project was initially addressed in an MDR that was released to ES Fox with preliminary assumptions regarding the size of the venting system that ES Fox and H/SL were required to validate.

As the design matured, additional decay heat studies were performed, ultimately resulting in the current design path in which the required filter system is substantially larger than initially assumed. Because the filter system was significantly larger than originally assumed, the size of the supporting structure for this duct system also had to be increased. Cost growth for these changes is under review but believed to be on the order of 18-30% over the early project estimate that is embedded in the current 4c Cost Estimate. This cost growth appears to be justifiable due to the increased scope, though the estimates for this additional cost should be vetted to ensure they are appropriate and properly priced.

The current schedule for CFVS forecasts a completion date of March 25, 2016. This work was originally contemplated to complete on November 17, 2015. The detailed level 3 schedule suffers from many of the same logic issues and poor critical path definition as noted for EPG3. These issues, as well as the potential cost growth, need to be addressed as soon as possible.

2. Risk Management Progress

In our 2Q 2014 Report, we identified that P&M was not utilizing the risk management process in an effective manner, and was merely using risk as a "check-the-box" activity as a prerequisite to obtaining funding for the work. The Refurbishment risk management team has been deployed to help P&M restructure its risk program, and risks are being collected and are now visible on the Project's risk register. However, there is some remaining confusion with the P&M team regarding on-going risk management. The DR Team is in the process of consolidating the risk management program under the Refurbishment organization, utilizing the same processes for risk identification and management with strong scrutiny by the DR Risk Oversight Committee. This should clear up any remaining inconsistencies.

3. Vendor Performance Issues

As noted, [redacted]

It is also worth noting that three of the four Campus Plan Projects that we have identified above as having concerns are being performed by ES Fox. While there is no evidence that we have seen that questions ES Fox's safety or quality record, and their team has thus far been very responsive to addressing any issues OPG has raised, the scope creep and cost increases evident in EPG3 and CFVS indicate that P&M should be just as vigilant in managing ES Fox's work. Any lessons from Campus Plan Projects should also be understood by the Refurbishment BOP team, who is using ES Fox for multiple scopes of work. P&M and Refurbishment BOP project managers need to vet ES Fox's estimating methodology, including how ES Fox is using factors for productivity, estimating project management team size and engineering costs, among other things.

- Completed CWPs formulated for DNGS;
- Variance reports showing differences between the OPEX driven Class 4 estimate and the current estimate;
- A Level 4 execution schedule;
- Detailed reports characterizing how SNC/Aecon prepared the estimate; and
- A well-defined risk register.

All of these SNC/Aecon products will require time for OPG to review and in this case it is our opinion that it is better to provide an extension of time than rush the review of such important material in order to meet a previously set deadline.

Concurrent with the development of the Class 3 estimate, SNC/Aecon is developing its Level 4 execution schedule. The first draft of this schedule was delivered on April 15, 2014 and ongoing review sessions are being held to refine it. First impressions of the schedule were that SNC/Aecon had not brought the best possible schedule for Unit 2 forward. It appeared that SNC/Aecon presented a comfortable, achievable schedule rather than an aggressive benchmark. This created a longer schedule than what would be considered a "target" schedule. In addition, several examples of incorrect logic and misalignment with OPG's level 1 schedule were identified. OPG is continuing to review and recommend changes prior to the delivery of the Schedule mini-report for the Class 3 estimate on April 30, 2014.

Looking forward from Class 3, it is important for OPG and SNC/Aecon to align around the plan and start preparing for the Class 2 estimate. As we have noted in prior reports, after SNC/Aecon completed the Class 4 estimate, there was a long period with no activity that only served to compress the preparation time for the Class 3 estimate, and that compression is at the root of the current need to rush through its approvals. As the Class 3 report is being developed, the team should endeavor to complete the Class 2 estimate plan so that any opportunities or progression points are identified early. In addition, the tool testing and productivity plan should be incorporated with the Class 2 estimate plan so that results are properly incorporated into the schedule and estimate. SNC/Aecon and OPG need to maintain focus on the finished product and what it means to be Class 2 RQE ready.

3. RWPB Building

The RWPB is being performed under many of the same conditions as the Campus Plan Projects as a pre-requisite to Refurbishment but by SNC/Aecon, the contractor performing the RFR retube work, rather than the ESMSA contractors. RWPB is facing very some familiar issues to those described above for D2O and AHS. The start of work is currently being impacted by the soil that was excavated from D2O Storage. There is a possibility the soil is contaminated, which has resulted in additional testing. In addition, the building has or will encounter plant operation coordination, and seismic issues have delayed foundation design and pushed out engineering. As of this report, engineering design complete is showing 43 days of negative float and installation/commissioning is showing an October 24, 2016 completion date. Although this schedule is immature and based on very preliminary engineering, the original plan was completion in June 2016 allowing three months before breaker open. It is vital for SNC/Aecon to utilize the lessons that are being learned from the F&I work in order to keep this building within a reasonable cost and schedule envelope. In addition, if there are cost increases, the Options Review Board should test the decisions being made with regard to building design in light of the fact that it is a temporary building that will be housing heavily contaminated materials. Further, the building should avoid any element of gold plating or permanent design.

4. RFR Commercial Risks

We recommended in our last report that the DR Team review some major provisions of the RFR contract in order to ensure that it will drive the proper behavior from SNC/Aecon in order to achieve success on the first unit and that OPG will be able to establish that it adequately and prudently considered the principles set forth in the government's Long Term Energy Plan ("LTEP")—primarily success on the first unit and ensuring appropriate risk shifting. This included re-visiting: (1) the performance incentives for unit-over-unit improvement as an incentive to the contractor to meet an aggressive schedule for the first unit; (2) whether the cost and schedule incentives/disincentives would drive the right contractor behavior; (3) the treatment and monetization of identified risks; and (4) whether to negotiate a guaranteed maximum price ("GMAX") once engineering is complete. In addition, OPG and SNC/Aecon will need to incorporate the

DARLINGTON REFURBISHMENT BUSINESS CASE SUMMARY

Darlington Operations Support Building Refurbishment

The purpose of this project is to extend the life of the Operations Support Building (OSB) to support the continued operations of the Darlington station. The OSB houses technical services that are essential to the operations of Darlington including security systems, site IT and telephone network hubs, quality assurance vault, station domestic water piping and safe access to the powerhouse via the bridge. This facility also provides office and conference room space for 375 station employees and various specialty groups inside the Darlington protected area.

The structure is now complete and in service.

Refurbishment Project Office

This facility acts as a secure entry point for Refurbishment workers and provides office space, a lunchroom, change room and parking space.

The full occupancy permit has been received, and move-in plans are being prepared for occupancy by year end 2015.

Electrical Power Distribution System

Electrical power from the grid is supplied to Darlington site facilities and buildings located outside the protected area by a feeder line from Hydro One's Wilson Transformer Station. This system was designed and installed 25 to 30 years ago, and had reached the end of its operational life. Capacity in the old system had diminished due to growth in electricity demand resulting from the addition of several new buildings on site. The performance and reliability of old system had gradually degraded over time and was not capable of supplying power to the new buildings needed to support Darlington Refurbishment and operations.

The site power distribution system was upgraded to meet the incremental demands of the new building/facilities, as well as to facilitate the supply of reliable electrical power to the existing and new buildings at the Darlington station. The upgrades included refurbishment/overhaul of the two old power distribution substations and construction of a new power distribution substation and associated distribution system.

The project is now complete and in service.

Re-tube & Feeder Replacement Island Support Annex

To provide office and meeting space for R&FR Contractor Management and OPG oversight teams, a facility is being constructed that will include shop space for contractors to perform pre-RFR fabrication and preparatory work activities.

Construction of the facility is nearing completion and is expected to be in-service in November 2015.

Vehicle Screening Facility

A facility was constructed to expedite vehicle traffic through security into the plant to enable higher priority vehicles to bypass traffic queues on the access road during periods of high construction traffic volume.

This project is complete and in service.

Re-tube Waste Processing Building

This facility is required to process waste in support of the R&FR project. Construction activities are underway and the facility is expected to be in service in December 2016.

4.1.2 Retube Waste Processing Building

This project includes the design, construction and commissioning of a Retube Waste Processing Building ("RWPB"). The RWPB will house a waste volume reduction tooling system, process intermediate-level refurbishment waste, and accommodate all low level waste container shipments for the DRP pursuant to OPG's radioactive waste management plans. Used reactor components will also be delivered from the outage unit to the RWPB in appropriately shielded flasks. The RWPB will enable OPG to optimize waste processing and packaging operations during the DRP. The RWPB is planned to be available for use in June 2017 and commissioning of the RWPB, including the waste tooling system, will be completed by July 2017.

4.1.3 RFR Execution Phase Work

The RFR Execution Phase work is scope that supports the primary reason for executing a refurbishment outage at Darlington. This scope includes the removal and replacement of each reactor's 480 fuel channel assemblies consisting of two end fittings, pressure tubes and calandria tubes, and the removal and replacement of the 960 feeder pipes in each reactor. Major activities also include the installation of new pressure tubes, new calandria tubes, new end fittings and the fabrication and installation of new feeders.

4.2 Turbine Generators

The Turbine Generators work bundle for Unit 2 is a maintenance outage (including turbine blade inspections). Unit 2 Turbine does not include any modifications in the field. It includes installation of a maintenance simulator to support training and testing, and is comprised of three broad areas of scope: (1) Turbine and Auxiliaries Work, (2) Moisture Separator Reheater Work, and (3) Generator and Auxiliaries.

Chart 2

Class of Estimate for the Major Work Bundles

Project	Estimate Class
RFR	Class 2
Turbine Generator	Class 2 - 3
Steam Generators	Class 2
Fuel Handling and Defueling	Class 3
Balance of Plant	Class 3 - 5
Facilities & Infrastructure Projects and Safety Improvement Opportunities	Class 1 - 3

As a Class 3 estimate, the RQE has an expected accuracy range of [-10 to -20% / +10 to +30%]. In their final oversight report to the OPG Board of Directors (Attachment 2), Burns & McDonnell Canada Ltd. and Modus Strategic Solutions Canada Company ("BMcD/Modus") conclude:

> Based on our nearly three years of oversight of the DR Project's planning, BMcD/Modus believes the process used for developing the control budget and critical path schedule that form the basis for RQE meets or exceeds industry thresholds. The control budget is based, most notably, on well-defined scope and detailed engineering, which has sufficiently matured to allow classification using the AACE International guidelines in the manner OPG intended for RQE. In addition, the level of detail in the RQE control budget is in line with our experience for projects of this nature and should form the basis for a robust project controls regime that will be used to track progress.

OPG engaged KPMG to provide an independent review of the governance and processes used to develop the RQE. KPMG's review consisted of (1) a governance and process assessment, and (2) a cross-cutting vertical slice review of the estimates. KPMG's final report arising from this review is provided in Attachment 3.

With respect to its governance and process assessment, KPMG assessed OPG's estimating governance and management processes associated with RQE development against relevant

Additional oversight for the RQE development process has been provided by BMcD/Modus. The RQE oversight provided by BMcD/Modus has been carried out as part of its broader role in providing DRP oversight. In particular, BMcD/Modus assessed the process used for developing RQE, with a particular focus on the development of detailed cost estimates that are of sufficient quality and basis in order to establish a four-unit, program level control budget for DRP. In addition to considering OPG's processes relative to its governance and industry guidance, particularly from AACE, BMcD/Modus considered whether the RQE process was sufficiently thorough and robust, whether contingency was developed in a manner consistent with industry practices and whether RQE was appropriately documented to permit vetting by senior management. A copy of the resulting BMcD/Modus report is provided in Attachment 2.

Based on its three years of DRP oversight, including one year with a particular focus on RQE, BMcD/Modus found that the processes used to develop RQE and the critical path schedule that forms the basis for RQE meets or exceeds industry thresholds. It found the RQE to be based on well-defined scope and detailed engineering, which was sufficiently mature to allow the intended classification based on AACE guidelines. The RQE was also found to be based on a level of detail in line with that seen for other projects of a similar nature, which will support a robust project controls regime to track progress. However, they also identified some risks associated with certain components of the RQE that, if not corrected before the Unit 2 full execution release in Q3 2016, could impact the Unit 2 estimate. OPG has therefore put a process in place to address the recommendations from BMcD/Modus and is tracking all actions to completion within this timeframe.

3.0 DRP COST BREAKDOWN

Chart 3 below provides a detailed cost breakdown of the RQE components.

Chart 3

DRP RQE Breakdown (M$)

#	Bundle / Category	RQE Total Cost	%
1	Retube & Feeder Replacement	3,598	28

#	Bundle / Category	RQE Total Cost	%
2	Turbine Generators	657	5
3	Balance of Plant	967	8
4	Fuel Handling/Defueling	198	2
5	Steam Generators	123	1
6	Subtotal Major Work Bundles	5,543	43
7	Facility and Infrastructure Projects	640	5
8	Safety Improvement Opportunities	205	2
9	Subtotal F&IP/ SIO	845	7
10	Project Execution	322	3
11	Contract Management	52	0
12	Engineering	283	2
13	Managed Systems Oversight	41	0
14	Planning & Controls	136	1
15	Nuclear Safety	83	1
16	Program Fees & Other Support	341	3
17	Supply Chain	86	1
18	Work Control	80	1
19	Operations & Maintenance	805	6
20	Early Release 3[1]	102	1
21	Early Release 4[1]	7	0
22	Subtotal OPG Functions	2,336	18
23	Contingency	1,706	13
24	Subtotal Before Interest & Escalation	10,429	81
25	Interest[2]	1,473	12
26	Escalation[3]	898	7
27	Subtotal Interest & Escalation	2,371	19
28	Total High Confidence Estimate	12,800	100

[1] Early Releases 3 and 4 are costs that were incurred during the preliminary planning phase of the Definition Phase before the DRP organization was in place. As a result, they cannot be attributed to the work bundles or functions. These costs are primarily related to EA, ISR and early planning work.

[2] Interest is applied monthly to cumulative capital expenditures in the previous months at a rate of 5 per cent until 2021, consistent with OPG's business planning assumptions and 6% thereafter.

[3] Escalation is set at 2 per cent on a per annum basis.

April 2015

performance, OPG is relying on accountability of the contractor, creation of the Vendor Leadership Forum and the execution construction organization's field presence as the strategy to address potential weaknesses by contractors. For core refurbishment projects, emphasis is being placed on having quality schedules and estimates for the completion of all aspects of the work and having the detailed schedules in place prior to a particular phase of the beginning.

m. Not responding to adverse trends in a timely and effective manner

These projects have had several, longstanding issues, starting with the D_2O storage project, but also cost estimates, development of reliable schedules, completion of engineering, performance of subcontractors and interfacing with the station to execute field work. Many of these issues existed for several months – some years. The P&M organization has not been effective at identifying and addressing performance issues in a timely and effective manner in order to limit their impact on safety, quality, cost and schedule delays. This behaviour of not identifying and addressing performance issues is similar to the cause of the Pt LePreau calandria tube insertion production and quality event.

Refurbishment management's strategy to reduce this risk includes the following items:

i. Establishing a meeting focus on performance against plan and the identification/resolution of issues.

ii. The future creation of a project Change Control Board.

iii. Creation of a Project Decision Making forum.

iv. Formalizing the purpose and function of the 'contrarian' in the deliberations of important program and project decisions.

v. Formalize the application and use of Event Free Challenge meetings for critical work.

These actions will support addressing this issue. However, there should be recognition and actions to improve the culture to drive issues to a more timely and effective resolution. The slow response to address the management of the large engineering backlog, the resolution of BOP and shutdown/layup/services contracts and the RWPB performance issues can be used to help refurbishment mid management understand the issue and the need for its reduction.

November 2013 in support of the release was a preliminary estimate and is not directly comparable to the RQE, as the scope of work was yet to be finalized. However, an approximation of the comparison is identified below:

Chart 1

	Ex. D-2-2-1 p.3 Chart 1		Nov. 2013 Total Cost Est (Release 4C)		
Program Component	**RQE Total Cost ($2015B)[1]**	**RQE Total Cost (%)**	**Total Cost Estimate Converted to 2015$[1]**	**Total Cost (%)**	**Total Cost Estimate (2013$)[2]**
Major Work Bundles	5.54	43	4.35	38	4.18
Safety Improvement Opportunities	0.20	2	0.11	1	0.11
Facilities & Infrastructure Projects	0.64	5	0.57	5	0.55
OPG Functional Support	2.23	17	2.16	19	2.08
Early Release Funds	0.11	1	0.12	1	0.12
Contingency	1.71	13	2.16	19	2.08
Interest & Escalation($B) [3]	2.37	19	1.97	17	2.20
Total Cost Estimate ($B) [3]	**12.8**	**100**	**11.32**	100	**11.32**

(1) All numbers are in 2015$ except for Interest and Escalation and the Total Cost Estimate
(2) All numbers are in 2013$ except for Interest and Escalation and the Total Cost Estimate
(3) Interest and Escalation and the Total Cost Estimate are in nominal dollars, i.e. a sum of the dollars of the year in which they are expended

c) OPG does not have enough detailed information on the costs estimates developed for such projects and the percentage of contingency in those estimates to do the comparison requested.

d) Please see Ex. L 4.3-1 Staff-45, part c).

e) The requested information for Facilities & Infrastructure Projects is shown in the following chart:

Chart 2

Project Title	Total Project Cost (M$)		% of costs Reclassified
	Original Full Release	EB-2016-0152	
Darlington OSB Refurbishment	53.0	62.7	100
DN Auxiliary Heating System	99.5	99.5	100
D2O Storage Facility	110.0	381.1	0
Water & Sewer Project	40.6	57.7	0
Darlington Energy Complex	105.4	105.4	0
R&FR Island Support Annex	40.7	40.7	0
Refurbishment Project Office	99.9	99.9	0
Electrical Power Distribution System	16.9	20.8	0
GM Office Facility	9.3	9.3	0
Vehicle Screening Facility	3.0	6.6	0

$305.4 $883.7

The requested information for the Safety Improvement Opportunities (SIO) projects is shown in the following chart. No SIO projects have been reclassified.

Chart 3

Project Title	Total Project Cost (M$)		% of costs Reclassified
	Original Release	EB-2016-0152	
Third Emergency Power Generator	88.2	120.4	0
Containment Filtered Venting System	80.6	80.3	0
Powerhouse Steam Venting System	5.6	5.6	0
Shield Tank Overpressure Protection	13.5	13.5	0
Emergency Service Water Buried Services	7.9	14.6	0

Note: The original release amounts for the SIO projects are based on the first approved Gate Progression Form or Change Control Form for Execution Phase.

$38.6 million $234.4

SIO + FI = $1118.1

August 2013

2. Additional Observations and Recommendations

As with any commercial strategy for a large capital project, there are risks associated with the multi-prime EPC model chosen by OPG for the DR Project. Many of these risks have been recognized and are being monitored by OPG, though they must be discussed on an ongoing basis as realization of some of these risks will impact the success or failure of the DR Project.

- With the multi-prime management approach, Owner's traditionally hire construction managers or program managers to coordinate the EPC contractors' work, and owner's engineers to review program compliance. OPG has chosen to fill these roles, and its success will be dependent its ability to employ a strong, capable and experienced construction management team that is able to effectively coordinate and track the work of such a large, complex project. We would also recommend that the DR Team integrate key construction management individuals into the DR Project Team as early as possible in the Definition Phase.
- OPG's preferred EPC contracting strategy is a new project delivery model introduced for the DR Project. It is also different from that used by OPG's vendors on past projects. Business cultural differences between OPG and vendors' management philosophies will have to be closely managed.
- The RFR contract dwarfs the other major project scopes, and there is a tendency to think of SNC/Aecon as the Project's full-wrap EPC contractor. This is not the case, and management needs to devote attention to the other projects to optimize adjacent project coordination and minimize interferences.
- The ESMSA vendors' performance and OPG's management of the vendors' work on the current Campus Plan scope has been mixed. OPEX from the D20 Storage Facility includes evidence of failures on both OPG's and the vendor's part to recognize that key details were missing from that project's definition which led to unrealistic schedule and readiness expectations[34]. The DR Team should examine these lessons learned going forward.
- The Program/Project approach has the risk of creating "silos" between the Project teams. Although each of the major Project Bundles are self-contained units, the Program must be managed by OPG as a whole, with a single, integrated schedule, cost control system and risk management approach.

Developing a contracting strategy for such a large project has to include a number of key variables. Some contracting approaches are more risky for the owner than others. Some are unsuitable for certain situations. Some strategies work for some owner organizations but do not work for others because the strategy depends on the owner's strengths. There is evidence that OPG took these major considerations into account in deciding on the contracting strategy it is following. However, this strategy will require some significant changes to OPG's prior large capital project mindset, and while growing pains are expected, the Project's success will be largely determined by OPG's willingness to embrace the role and recognize and control the risks associated with the chosen method.

C. Project Controls

OPG's Project Controls team is responsible for essential functions of Schedule, Budget, Risk Management and Document Control. The following is our assessment of the development of each of these key elements to date.

[34] D20 Storage and Drum Handling Project: Modification Planning Lessons Learned Report, D-LLD-38000-1001 (March 4, 2013)

January 2016

1. Minister Summary

Previous quarterly reports provided a detailed quarterly review of trends, accomplishments and challenges related to the Darlington Nuclear refurbishment project. With the completion of the Definition Phase at 2015 yearend, the focus of the refurbishment project has transitioned into execution of its Ready to Execute (RTE) Plan.

A number of achievements have been made through the Definition Phase of the project; including:

- The Release Quality Estimate for the refurbishment of the four Darlington units was prepared and approved by the OPG Board of Directors. This included the estimated cost (including contingency) and duration for the defined scope of work for the four units.
- The OPG contracting strategy was developed and implemented. This contracting strategy is designed to retain vendors best qualified to perform the work contracted to them, while appropriately transferring risk and minimizing risk premium. The key risks are associated with safety, quality, cost overruns and schedule extensions. Of the $12.8B high confidence total cost estimate of the Darlington Refurbishment Project, $5.3B (including the $0.8B spent to date) has or is to be spent by contractors for the engineering, planning, procurement and field execution of the five core refurbishment project bundles.
- OPG declared success in meeting the August 15, 2015 milestone for the completion of design engineering. However, this was accomplished with a large number of outstanding items for resolution. As stated in previous reports, the process to accept design agency deliverables may not be sufficiently rigorous to ensure high quality products. This risk has been realized in a number of projects, most recently the STOP (Shield Tank Overpressure Protection) project. The design was incorrect in assumptions regarding the size of the pressure pulse when switching pumps. This resulted in the field installation during the Unit 3 fall outage not being acceptable, removed from service, and the unit returned to service without the modification installed. The response to this event should include a review of the extent of condition and cause.
- OPG has received the required regulatory approvals for the refurbishment of the four units. This includes approval of the Environmental Assessment, the Integrated Safety Review that includes Component Condition Reports and the Global Assessment, and the Integrated

January 2015

Lesson Learned	Basis	OPG actions and effectiveness	Likelihood of recurrence
Poor cost estimates	OPG recognizes that several of these projects were started and continued without the appropriate level of cost estimate.	There is increased rigour in the cost estimates for the core projects and revised estimates for these projects. This includes collaborative front end planning for a better understanding of the scope of work and the use of third party estimates for comparison.	Low
Poor execution schedules	Many of these projects started and continued without detailed schedules for engineering and field activities. There is an effort to recover this problem as the projects are in progress.	OPG is supporting the vendors in the development of detailed schedules. There is a requirement for detailed schedules as part of the gate review process. Currently there are struggles obtaining detailed schedules for engineering deliverables.	Medium
Completion of engineering prior to the start of field execution	These projects have started prior to the completion of engineering. Currently there are examples of design engineering delaying field execution in these projects. This will likely continue through the completion of these projects.	This is one of the high level lessons learned that OPG addressed through its infrastructure and milestones for the refurbishment project. That is the basis for having the engineering complete milestone a year prior to the start of the Unit's refurbishment outage. Even with the current challenges in managing the engineering workload, there is sufficient float to complete engineering by the start of execution.	Low

January 2015

Lesson Learned	Basis	OPG actions and effectiveness	Likelihood of recurrence
Management of subcontractors	These projects have had issues with the performance of subcontractors. Issues have included the delivery of engineering products in a timely manner, some engineering quality problems, timely delivery of parts, some quality issues related to parts manufacture, field execution rework and safety performance.	Similar issues have started with the management of subcontractors for core refurbishment projects.	High
Not effectively using station processes	There are a number of station processes which are required to be used by the contractors, but are not effectively implemented. These include work management processes, work protection, work authorization, event free challenge process, etc. Refurbishment operations and maintenance is assisting in facilitating the ESMSA contractors through some of these processes.	It is assumed that the contractors and subcontractors will have processes similar to the OPG processes. This is believed to be a contractual requirement. Processes have not been fully aligned or equivalent in the few cases that have been tested. For example, during Q4 there have been incidents involving lifting and rigging with both the Joint Venture and ES Fox. The initial Turbine Generator FME plan was rejected.	Medium

July 2015

The following Lessons Learned have a medium likelihood of recurrence without on-going management focus and successful completion of planned actions:

b. Completion of engineering prior to the start of field execution

Many of the Campus Plan and Safety Improvement Opportunities (SIO) projects started and continued field construction without the completion of detailed engineering. This continues for some important projects such as EPG 3, CFVS, D_2O Storage Building and the Auxiliary Heating System. This has contributed to on-going revisions to costs and schedules. These projects demonstrate the consequences of not starting field execution before engineering is actually completed. This was previously identified by OPG refurbishment management as one of the major lessons learned from previous refurbishment and large nuclear projects. Engineering must be completed prior to the start of field execution. As a result, OPG established a milestone for the completion of engineering of August 2015. Even with the current challenges in managing the engineering workload, there is sufficient float to complete engineering for the projects being executed after Unit 2 breaker open.

The current challenge is for core refurbishment projects that are being executed prior to Unit 2 breaker open. The RWPB has started construction without completion of engineering or nuclear safety analysis. It is recognized that engineering has been done for the portions of procurement and construction that have started, but this is not the standard of engineering complete prior to start of construction that refurbishment management is striving. It is not surprising that cost and duration estimates have been revised on a number of occasions. The current cost estimate is $108M and target completion date of December, 2016.

In addition, there are several shutdown/layup/services and support projects to be executed in 2015 and 2016, as prerequisites to breaker open. These include Breathing Air installation, Service Air installation, Negative Pressure Containment modifications and several facilities. The August 15th milestone for completion of engineering will not be met for some of these projects and this results in downstream impacts of the procurement of materials and generation of CWPs. Refurbishment management is initiating a plan to manage the impact of the late engineering.

c. Poor engineering and field execution schedules

Through the duration of the Campus Plan and Safety Improvement Opportunity projects, the organization has been plagued with inaccurate and unreliable

OPG ACTIONS TAKEN/PLANNED IN ALIGNMENT WITH LTEP PRINCIPLES

2013 LTEP – Nuclear Refurbishment Principles	OPG Actions Taken/Planned in Alignment with LTEP Principles
Minimize commercial risk on the part of ratepayers and government	• Locked down project scope well in advance of starting construction; • Fully developed engineering and planning of the work so that it is 100 per cent complete prior to the start of construction; • Built a full-scale mock-up of the Darlington reactor and vault and used them to fully test the tools and determine tooling durations in order to build a reliable schedule. All workers will be trained using the tools in the mock-up prior to working in the plant; • In phases, developed a Release Quality Estimate that incorporates a high-confidence budget and schedule for the work; • "Unlapped" Unit 2 from subsequent units so that the focus can be on planning and construction of a single unit to ensure its success while documenting lessons learned from the first unit and applying them to work processes on subsequent units; • Utilizing target price contracts for the execution phase that are based on developing cooperation, transparency, and risk sharing with key vendors; • Utilizing fixed price contracts for certain execution phase scope that is well defined and where risk transfer to a third party is appropriate; • Negotiated various off-ramps and stages into contracts; and • Established a robust risk management process to directly identify and administer commercial risks.
Mitigate reliability risks by developing contingency plans that include alternative supply options if contract and other objectives are at risk of non-fulfillment	• Decision to "unlap" Unit 2 from the other unit refurbishments, which predated the LTEP, was intended to mitigate performance risk and allow the DRP team to focus on refurbishing the first unit prior to commencing subsequent units. If the first unit is not successful, off-ramps are in place; the second unit refurbishment will not commence until the first unit is successfully returned to service. • Risk assessment and appropriate contingency and mitigation plans for each execution work package have been developed. • OPG's investment in the reactor mock-up is being used to perform full integration and commission testing of tools needed for refurbishment; lessons are being learned on the mock-up,

GEC Interrogatory #4

Issue Number: 4.5
Issue: Are the proposed test period in-service additions for the Darlington Refurbishment Program appropriate?

Interrogatory

Reference:
Exhibit D2-2-11 Attachment 3 Page 9 of 122
"It is typical for megaprograms, such as the DRP, to be managed on a planned duration that is less time than reflected in the high-confidence schedule."

And at p. 10 "The Facilities and Infrastructure Projects (F&IP) and Safety Improvement Opportunities (SIO) were not necessarily completed per the initial planned schedule and estimate…"

a) Please provide details of the various percentage schedule delays and percentage cost overruns in the F&IP and SIO projects relative to the high confidence schedule and estimate and the planned schedule and estimate.

b) Please provide an analysis of the degree of adherence to date to the high confidence and the panned schedules for each major work component of the DRP. Please do so with reference to the highest level schedule (as described at page 31 of the Pegasus evidence) that existed at the time of OPG's prior OEB application and with respect to the initial version of the level 5 schedule.

c) Please provide a complete history of the DRP's expected unit completion dates and outage duration schedules showing initial assumptions and changes to date.

Response

a) The F&IP and SIO projects were not planned in the same manner as the Unit 2 refurbishment outage, with planned (target) and high confidence schedules and estimates. OPG is therefore unable to provide the analysis requested. Variance explanations for F&IP projects greater than $20M, where the project cost variance was greater than 10% are provided in Ex. D2-2-10, pp. 11-22.

b) As OPG has just begun to execute the refurbishment outage on Unit 2 (Breaker Open was on October 15, 2016), this analysis is not possible.

Witness Panel: Darlington Refurbishment Program

SEC Interrogatory #15

Issue Number: 4.3
Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:
[D2/2/3, p.11-14]

Please provide a similar chart showing the following scenarios for the RFR Target Pricing:

a) Contractor cost overrun of 25%

b) Contractor cost overrun of 50%

c) Contractor cost overrun of 75%

d) Contractor cost overrun of 100%

Response

OPG provides the requested scenarios below as illustrative examples to demonstrate how the Retube and Feeder Replacement (RFR) contract mechanisms work. OPG notes, however, that at cost overruns such as those contemplated by the requested scenarios, OPG would have taken a number of actions before these levels were reached. OPG also carries contingency for certain events. Furthermore, these examples do not consider schedule impacts, which would likely drive different outcomes at the overrun thresholds contemplated in the requested scenarios. Also, OPG notes that as the mock-up is complete, the inclusion of the mock-up overruns in the examples is for illustration only and to reflect the original example in the evidence at Ex. D2-2-3. Finally, although OPG's contract with the SNC/AECON Joint Venture utilizes cost-plus mark-up pricing for the owner specified materials (OSM), a large portion of the SNC/AECON Joint Venture's contracts with its subcontractors for this work is on a fixed/firm price model, and therefore the cost overruns depicted below are unlikely.

For all of the scenarios below, all the same features and assumptions for Charts 4-7 in Ex. D2-2-3 apply:

- Scenarios are based on approved scope at the time of the Release Quality Estimate.
- The contractor Fixed Fee was negotiated as a percentage of target cost. Once established, the Fixed Fee paid by OPG does not change as actual costs change, and is subject to the incentive/disincentive mechanism. In the examples, the "contractor cost" for the Fixed Fee varies with the scenarios to represent changes in contractor overheads and profits based on changes in actual costs.

- For simplicity, an incentive or disincentive adjustment of 20% is used for target cost savings or overruns outside of the neutral band. The actual percentage is calculated using a graded approach.
- Also for simplicity, the cost categories of OSM, Reimbursable Costs and Goods assume the increased costs all include any contractor markups, and any cost savings or overruns are excluded from the Fixed Fee incentives/disincentives.
- No schedule disincentives are applied.
- The numbers may not add due to rounding.

a) In the first scenario set out in Chart 1 below, the contractor incurs a 25% cost overrun. For the fixed fee or price portions of work, there is no negative cost impact to OPG (Chart 1, lines 2, 5, 7 and 9). For the target cost portions of work, OPG reimburses the actual (allowed) costs of the contractor and pays the cost variance to the contractor (Chart 1, lines 1 and 4). For the Definition Phase Target Cost, the cost variance is $46M (Chart 1, line 1), which is outside of the $2.5M Definition Phase neutral band. The contractor must pay OPG a Definition Phase disincentive payment of $9M (Chart 1, line 3). Additionally, for the Execution Phase Target Cost, the cost variance is $417M (Chart 1, line 4), which is also outside of the Execution Phase neutral band of $75M. The contractor must pay OPG a disincentive of $68M (Chart 1, line 6). OSM and Goods are paid at actual costs and the cost overrun is paid by OPG.

Chart 1 – Contractor Cost Overrun of 25%

			% Contractor Cost Overrun = 25%				
#	Category ($ Million)	Contract Costs (from table 3)	Contractor Cost	Cost Variance	Impact to Contractor	Impact to OPG	OPG Payment to Contractor
1	Definition Phase Target Cost (Incl RWPB)	185	231	46	0	46	231
2	Definition Phase Fixed Fee	74	92	18	18	0	74
3	Definition Phase Fixed Fee Incentive/ Disincentive				9	(9)	(9)
4	Execution Phase Target Cost	1,667	2,084	417	0	417	2,084
5	Execution Phase Fixed Fee	492	615	123	123	0	492
6	Execution Phase Fixed Fee Incentive/ Disincentive				68	(68)	(68)
7	Mock-up Fixed Price	38	48	10	10	0	38
8	Non-target Reimbursable Costs	6	8	2	0	2	8
9	Tooling Fixed Price	375	469	94	94	0	375
10	OSM with Fee(estimate)	579	724	145	0	145	724
11	Goods with Fee(estimate)	[illegible]	60	12	0	12	60
12	Total	3,464	4,329	866	322	544	4,008

b) In the second scenario set out in Chart 2 below, the contractor incurs a 50% cost overrun. For the fixed fee or price portions of work, there is no negative cost impact to OPG (Chart 2, lines 2, 5, 7 and 9). For the target cost portions of work, OPG reimburses the actual (allowed) costs of the contractor and pays the cost variance to the contractor (Chart 2, lines 1 and 4). For the Definition Phase Target Cost, the cost variance is $93M (Chart 2, line 1), which is outside of the $2.5M Definition Phase neutral band. The contractor must pay OPG a Definition Phase disincentive payment of $18M (Chart 2, line 3). Additionally, for the Execution Phase Target Cost, the cost variance is $834M (Chart 2, line 4), which is also outside of the Execution Phase neutral band of $75M. The

contractor must pay OPG an Execution Phase disincentive payment of $152M (Chart 2, line 6). OSM and Goods are paid at actual costs and the cost overrun is paid by OPG.

Chart 2 – Contractor Cost Overrun of 50%

			% Contractor Cost Overrun = 50%				
#	Category ($ Million)	Contract Costs (from table 3)	Contractor Cost	Cost Variance	Impact to Contractor	Impact to OPG	OPG Payment to Contractor
1	Definition Phase Target Cost (Incl RWPB)	185	278	93	0	93	278
2	Definition Phase Fixed Fee	74	110	37	37	0	74
3	Definition Phase Fixed Fee Incentive/ Disincentive				18	(18)	(18)
4	Execution Phase Target Cost	1,667	2,501	834	0	834	2,501
5	Execution Phase Fixed Fee	492	738	246	246	0	492
6	Execution Phase Fixed Fee Incentive/ Disincentive				152	(152)	(152)
7	Mock-up Fixed Price	38	57	19	19	0	38
8	Non-target Reimbursable Costs	6	9	3	0	3	9
9	Tooling Fixed Price	375	563	188	188	0	375
10	OSM with Fee(estimate)	579	869	290	0	290	869
11	Goods with Fee(estimate)	48	72	24	0	24	72
12	Total	3,464	5,195	1,732	659	1,073	4,536

c) In the third scenario set out in Chart 3 below, the contractor incurs a 75% cost overrun. For the fixed fee or price portions of work, there is no negative cost impact to OPG (Chart 3, lines 2, 5, 7 and 9). For the target cost portions of work, OPG reimburses the actual (allowed) costs of the contractor and pays the cost variance to the contractor (Chart 3, lines 1 and 4). For the Definition Phase Target Cost, the cost variance is $139M (Chart 3, line 1), which is outside of the $2.5M Definition Phase neutral band. The contractor must pay OPG a Definition Phase disincentive payment of $27M (Chart 3, line 3). Additionally, for the Execution Phase Target Cost, the cost variance is $1,250M (Chart 3, line 4), which is also outside of the Execution Phase neutral band of $75M. The contractor must pay OPG an Execution Phase disincentive payment of $235M (Chart 3, line 6). OSM and Goods are paid at actual costs and the cost overrun is paid by OPG.

Chart 3 – Contractor Cost Overrun of 75%

			% Contractor Cost Overrun = 75%				
#	Category ($ Million)	Contract Costs (from table 3)	Contractor Cost	Cost Variance	Impact to Contractor	Impact to OPG	OPG Payment to Contractor
1	Definition Phase Target Cost (Incl RWPB)	185	324	139	0	139	324
2	Definition Phase Fixed Fee	74	129	55	55	0	74
3	Definition Phase Fixed Fee Incentive/ Disincentive				27	(27)	(27)
4	Execution Phase Target Cost	1,667	2,917	1,250	0	1,250	2,917
5	Execution Phase Fixed Fee	492	861	369	369	0	492
6	Execution Phase Fixed Fee Incentive/ Disincentive				235	(235)	(235)
7	Mock-up Fixed Price	38	67	29	29	0	38
8	Non-target Reimbursable Costs	6	11	5	0	5	11
9	Tooling Fixed Price	375	656	281	281	0	375
10	OSM with Fee(estimate)	579	1,013	434	0	434	1,013
11	Goods with Fee(estimate)	48	84	36	0	36	84
12	Total	3,464	6,061	2,598	996	1,601	5,065

d) In the fourth scenario set out in Chart 4 below, the contractor incurs a 100% cost overrun. For the fixed fee or price portions of work, there is no negative cost impact to OPG (Chart 4, lines 2, 5, 7 and 9). For the target cost portions of work, OPG reimburses the actual (allowed) costs of the contractor and pays the cost variance to the contractor (Chart 4, lines 1 and 4). For the Definition Phase Target Cost, the cost variance is $185M (Chart 4, line 1), which is outside of the $2.5M Definition Phase neutral band. Because the Definition Phase Cost Disincentive is capped at 48% of the Definition Phase Fixed Fee, the contractor must pay OPG a Definition Phase disincentive payment of $35M (as opposed to $36M) (Chart 4, line 3). Additionally, for the Execution Phase Target Cost, the cost variance is $1,667M (Chart 4, line 4), which is also outside of the Execution Phase neutral band of $75M. Similarly, because the Execution Phase Cost Disincentive is capped at 48% of the Execution Phase Fixed Fee, the contractor must pay OPG an Execution Phase disincentive payment of $236M (as opposed to $318M) (Chart 4, line 6). OSM and Goods are paid at actual costs and the cost overrun is paid by OPG.

Chart 4 – Contractor Cost Overrun of 100%

			% Contractor Cost Overrun = 100%				
#	Category ($ Million)	Contract Costs (from table 3)	Contractor Cost	Cost Variance	Impact to Contractor	Impact to OPG	OPG Payment to Contractor
1	Definition Phase Target Cost (Incl RWPB)	185	370	185	0	185	370
2	Definition Phase Fixed Fee	74	147	74	74	0	74
3	Definition Phase Fixed Fee Incentive/ Disincentive				35	(35)	(35)
4	Execution Phase Target Cost	1,667	3,334	1,667	0	1,667	3,334
5	Execution Phase Fixed Fee	492	984	492	492	0	492
6	Execution Phase Fixed Fee Incentive/ Disincentive				236	(236)	(236)
7	Mock-up Fixed Price	38	76	38	38	0	38
8	Non-target Reimbursable Costs	6	12	6	0	6	12
9	Tooling Fixed Price	375	750	375	375	0	375
10	OSM with Fee(estimate)	579	1,158	579	0	579	1,158
11	Goods with Fee(estimate)	48	96	48	0	48	96
12	Total	3,464	6,927	3,464	1,250	2,214	5,677

AMPCO Interrogatory #101

Issue Number: 4.3
Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:
Ref: D2-2-11 Attachment 1

a) Page 5: Concentric indicates it did not independently verify the appropriateness, sufficiency or correctness of the Program schedules, cost estimates, or scope. Please confirm the third party that undertook this verification.

b) Page 6: Please provide OPG's benchmarking analysis of its Program against other CANDU refurbishments such as those at the Wolsong nuclear plant in South Korea, the Bruce nuclear plant in Ontario, and the Pt. Lapreau nuclear plant in New Brunswick.

Response

a) There was no third party review undertaken to verify or validate the final schedule duration, cost estimate, or scope definition for the refurbishment. The purpose of the third party reviews of the RQE was to validate that the processes and practices to develop the final cost, schedule, and scope for refurbishment met or exceeded industry standards, and, to confirm that OPG was effectively following those processes and practices.

b) Please refer to Ex. L-4.3-2 AMPCO-52.

Generation has divided the work into multiple major work packages, of which Retube & Feeder Replacement is one.

Ontario Power Generation's selection of the multi-prime strategy was based on the recognition that alternative models have not been successful, and that there is a reasonable need to retain control of, and project management responsibility for, the Project. Specifically, Ontario Power Generation will retain control over deliverables, work processes, the scope of work, and the ultimate design of station modifications and replacements. Ontario Power Generation will also retain responsibility for planning and permitting, coordinating the interfaces between each of the prime vendors selected to complete the work packages, and overseeing the Project's multiple prime contractors. Finally, Ontario Power Generation will be responsible for vendor claims for scope changes, owner-caused delays and vendor-caused delays that affect other vendors (setting aside the Company's recourse to the vendor causing the delay). Importantly, the multi-prime strategy will provide Ontario Power Generation with additional flexibility to transfer work between major vendors if such a transfer promotes efficiency and value for money.

By using this model, Ontario Power Generation is accepting the challenge of managing each of the prime vendors and ensuring that each vendor is able to complete its work according to its plan. Given the complexity of the Project and the limited working space within the Darlington site, Ontario Power Generation's coordination of the various work tasks will require extensive planning to prevent claims of delay or increased costs caused by Ontario Power Generation's failure to adequately plan and coordinate the work or interference from another vendor.

C. CONCENTRIC'S OPINION OF THE OVERALL PROJECT COMMERCIAL STRATEGY

Concentric believes Ontario Power Generation has acted prudently in selecting the multi-prime contractor model strategy. Ontario Power Generation's selection of this commercial strategy appropriately and reasonably considered the operational experiences of refurbishment projects at the Bruce A and Point Lepreau refurbishment projects, and the restart of Pickering A. This model provides Ontario Power Generation with the necessary control over the design and planning of the Project and allows Ontario Power Generation to utilize the expertise of specialty vendors in a cost effective manner. We note that a variation of this model is being used to successfully deploy new nuclear facilities in China. In that model, a Chinese state-owned entity is sponsoring nuclear construction projects at Sanmen and Haiying. A local construction company is being utilized to construct the projects while a consortium of the Shaw Group, Inc. and Westinghouse Electric Company, LLC is providing engineering, procurement and construction ("EPC") oversight services. Finally, a recent analysis has shown that this model is likely to result in total project costs that are at least competitive with, if not lower than, alternative commercial strategies.[9]

While Concentric is in agreement with the selected commercial strategy, we do note that this model does not mirror Ontario Power Generation's previous experience with significant projects and that the Project team has limited experience in managing vendors under this model. Ontario Power Generation's limited experience in managing the vendor oversight function in a large, diverse, multi-prime contracting model will increase the importance of accessing external resources. Ontario Power Generation is appropriately meeting this need through a combination of Owner's Support Services vendors, and other outside consultants and

[9] Rojas, Eddy M., "Single Versus Prime Contracting," *Journal of Construction Engineering and Management*, October 2008, pp. 758-765.

SEC Interrogatory #33

Issue Number: 4.3
Issue: Are the proposed nuclear capital expenditures and/or financial commitments for the Darlington Refurbishment Program reasonable?

Interrogatory

Reference:
[D2/2/8, Attach 3] With respect to KPMG, *RQE Governance & Process Review and RQE Cross Cutting Vertical Slice Review* (November 6 2015):

> Who are the authors of the KPMG Report? Please provide a copy of their CVs. Please include what relevant experience they have conducting cost estimate reviews of similar projects of the size and scope of the DRP.

a. [p.7, Table 2] Please confirm the risk categories are those defined by KPMG and not AACE.

b. [p.57] KPMG states that for the purposes of primary research, it conducted interviews with three employees who had experience planning and managing nuclear refurbishment projects. Please provide a copy of all notes, transcripts, memorandums, or similar documents detailing those interviews.

c. [p.57] KPMG lists 9 other nuclear refurbishment and/or construction projects that it researched for the purposes of providing best practices and lessons learned. Please provide a copy of all documents that KPMG reviewed.

d. [p.75] Please provide a copy of the Program level Basis of Estimate.

Response

The following responses have been prepared by the KPMG Major Project Advisory team (their CVs are filed as Attachment 1):

a) Confirmed. KPMG conducted a governance and process review on the basis of AACE and KPMG Major Project Advisory leading practices. KPMG further performed a cross cutting review of estimate documentation and reported on overall traceability, data integrity, and level of detail in the preparation of the RQE. KPMG did not report on the accuracy of the cost figures (not included in KPMG scope). Gaps and recommendations identified through this review were then categorized into risk categories as defined and assessed by KPMG, and are not specific to AACE.

b) Please refer to Attachment 2 for the notes from the interviews. For clarification and as stated in the report, this primary research involved interviews with three "individuals" who are experienced industry professionals, not three "employees" as stated in the question above.

c) Please refer to the Project Reports in Attachment 3 for the notes from KPMG's review of the other nuclear refurbishment projects.

Please note that the Project Report in Attachment 3 is marked "Confidential", however, KPMG has determined it to be non-confidential.

d) The Release Quality Estimate Basis of Estimate Report is provided in Attachment 4.

commercial strategy change (i.e. the abandonment of the project management model and the adoption of the multi-prime model).

Engineering

From 2008 to 2011, Engineering completed a detailed set of component condition assessments (CCA's) in order to determine preliminary scope for the project. Since that time, some CCA's have been further developed, and engineering studies have been completed in order to finalize DRP scope.

By mid 2014, over 180 owner-specified modification design packages (MDP's) had been prepared. These MDP's define the scope requirements and are provided to the major project contractors in order to perform detailed engineering. As of September 30, 2015, detailed engineering was completed on over 200 engineering change (EC) modification packages by the major project contractors. Owner Engineering, as the Design Authority, is working collaboratively with the contractors to ensure requirements are understood, while providing oversight of all engineering deliverables being prepared by each contractor working on the DRP.

Substantial completion of detailed engineering 14 months in advance of the start of unit 2 refurbishment was central in the development of the high confidence RQE, and supports downstream procurement and work planning activities that are occurring during the preparation for Execution Phase.

Cost Recovery and Financing

Cost recovery and financing confirmation is underway; however, is not currently in place. OPG will recover prudently incurred costs via the Ontario Energy Board (OEB) rate approval process (O. Reg. 53/05) once the units are refurbished and returned to service. The risk is that there is no assurance that all costs are recoverable through this process.

OPG continues to discuss with the Province the need for greater assurance of cost recovery and has suggested regulatory changes to facilitate this. The Province continues to support the DRP which has also been endorsed by the Long Term Energy Plan .

b. **Major Projects**

Re-tube & Feeder Replacement

The R&FR work package determines the DRP's critical path. This work package includes the removal and replacement of each reactor's 480 pressure tubes and calandria tubes, and the removal and replacement of the 960 feeder pipes in each reactor.

OPG initiated the R&FR contracting process in 2010 by issuing a request for expressions of interest. OPG received submissions from seven potential contractors. Based on the responses received, pre-qualification of the potential contractors, and the subsequent partnering by potential contractors, OPG issued a Request for Proposal (RFP) in March 2011. Responses to the RFP were received on June 26, 2011. OPG continued negotiations with two proponents in an effort to reach acceptable commercial terms. OPG then required each proponent to submit their final proposals based on the negotiated terms. The SNC/AECON consortium was selected and OPG executed a final agreement with the consortium on March 1, 2012.

The contracting strategy selected by OPG for the R&FR work package includes an Engineering, Procurement and Construction (EPC) arrangement that combines fixed/firm pricing for known or highly definable tasks and a target price for the remaining scope of the R&FR work package where work is less definable. The work is phased with a project schedule comprised of a definition phase, an execution phase and a commissioning phase.

public. Between the years 2009 to 2012, the DR Project's overall budget has grown by ~$1.5B (2012 dollars) which is equivalent to ~20% of initial budget. The current point-estimate of ~$9.3B ($2012 dollars) in the 2013 Business Plan is approaching the upper boundary of the budgeted range of ~$10.8B ($2012) latest approved by the BOD. This total increase represents in large part scope growth of the DR Project. There are many reasons for this growth, including:

- OPEX, in particular from PARTS, which had significant cost overruns and schedule delays due to lack of scope definition at that project's outset has led the DR Team to conservatively identify a broad range of potential refurbishment scope;
- In the scope identification process, there appears to have been a tendency to increase scope to maintain the Station's WANO standing as well as over-commit to regulatory-driven modifications;
- As the scope of the Project has become more in-focus, the size of the Project Team has grown to match the effort represented;
- OPG decided to shift the OPS & Maintenance cost for each unit's operators to the DR Project while under refurbishment, which further added to the overhead costs.

The DR Team's SVPs have a firm understanding that, going forward, if scope is not effectively managed (and in some cases significantly reduced), OPG's management will be hard-pressed to deliver the DR Project at an acceptable cost. Below we discuss the progression of the DR Project's cost estimate, assess the current DR Team effort to examine and vet scope, and provide other recommendations for OPG to consider.

1. Budget and Scope History

BMcD/Modus's starting point in reviewing the DR Project's scope was to review the evolution of Management's representations to the BOD. The following summarizes the presentations that Management has given to the BOD regarding the evolution of the DR Project's budget and associated scope:

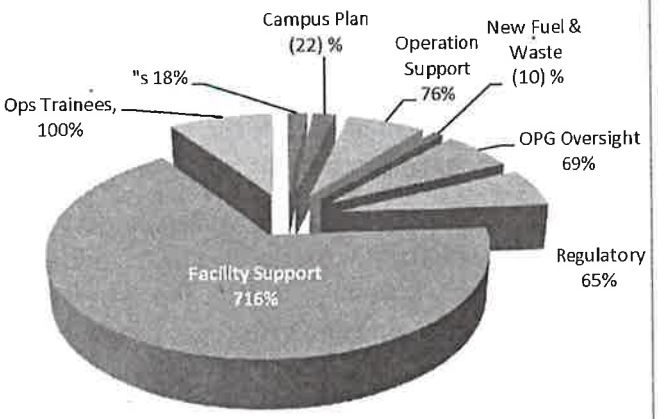
- On November 18, 2008, the BOD was presented an initial "medium confidence" cost estimate of ~$4.9B including a 20% contingency. At that time, the basis of the cost estimate included a 2007 Pickering B Assessment; industry studies; and considerations emanating from OPG's own operating experience (OPEX).[12]
- In year 2009, Rev 3 of the cost estimate was developed by the Project Control Team which totaled ~$7.7B[13].
- On March 5, 2010, Management committed to the BOD that the DR Project's scope would be limited to: (1) replace life-limiting components (such as pressure tubes) to allow OPG to operate the units for an additional 30 years, and; (2) replacement of components most effectively done in an extended outage. Management assured the NOC that the DR Project had processes in place to control scope growth via the Scope Review Board, which will "ensure that appropriate reviews (technical and financial) are being performed to ensure that scope is appropriate and minimized to the extent feasible to avoid increasing the complexity of the project and impacting the project's critical path."[14]

[12] Report for Submission to Nuclear Generation Projects Committee (November 18, 2008) at p. 8.
[13] Report for Submission to Nuclear Generation Projects Committee (November 17, 2009) at p. 1.
[14] Update on Darlington Refurbishment Project (March 5, 2010) at p. 1.

- On November 17, 2011, the BOD was presented with a cost estimate that was characterized as remaining in the range of ~$6.3B to ~$10.5B[15] Additionally, the DR Team's 2012 Business Plan estimate was ~$8.7B.
- On November 15, 2012 management presented its 2013 Business Plan cost estimate with a high confidence amount of ~$9.3B in 2012 dollars, thus including escalation, which remained less than $10B in 2009$. There were additional details and explanation of variances within the materials presented with the 2013 Business Plan.[16]

Based on files made available, variances and explanations of overall Program scope growth between 2009 and 2012 are summarized below:[17]

- Operations Support grew by $386M or 76% based on required human resource profile considerations, all as prepared by Operations and Maintenance Organization.
- OPG project management projections grew by $443M or 69% based on enhanced definitions and refined organizational characteristics of each department. Currently, the project management estimate is ~20% of total direct costs.
- Regulatory expenses grew by $71M or 65%, primarily due to CNSC fees.



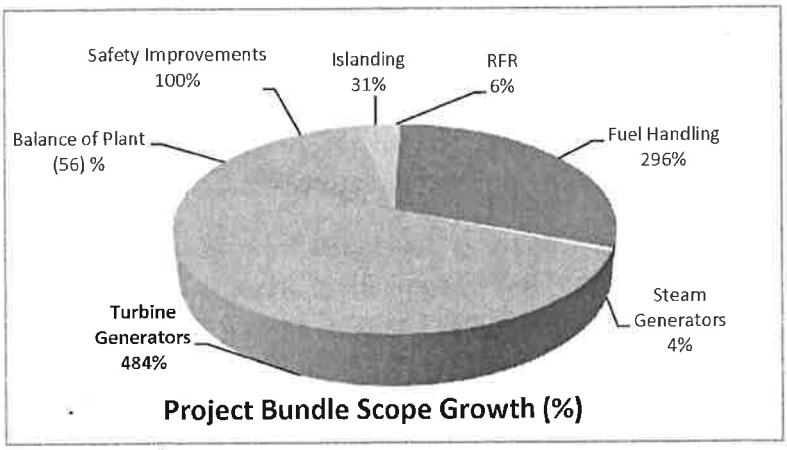
Overall Program Scope Growth (%)

- Facility Support grew by $86M or 716%. Projected costs were reflective of corporate real estate (CRED) support costs at the Darlington Energy Center (DEC) along with business trade union (BTU) costs to maintain site facilities.
- Operation Training grew by $27M or 100%.
- Project Bundles grew by $568M or 18% overall, resulting from enhanced work definition; increased maturity; increased scope of the Turbine Generator Project and addition of safety improvement opportunity (SIO) projects.
- Campus Plan costs decreased by $146M or 22% due to improved scope clarity.
- New fuel and Waste work decreased by $34M or 10% due also to improved scope clarity.

The variances between the 2012 and 2013 Business Plans for the Project Bundles which comprise the bulk of direct costs are summarized below:

[15] Update on the Darlington Refurbishment Project Economics (November 17, 2011) at p. B-1.
[16] Update on the Darlington Refurbishment Project Economics (November 15, 2012) at p. 3.
[17] See DNGS Refurbishment Estimate Analysis (April 25, 2013) at p. 4.

- The RFR scope grew by $154M or 6% via improved definition and development of a more refined cost estimate.
- The Fuel Handling scope increased by $125M or 296% based on detailed review of Fuel Handling – Component Condition Assessment and continued scope clarification.
- The Steam Generator scope grew by $7M or 4% due to a revised cost estimate.



- The Turbine Generator scope grew by $287M or 484% due to the addition of the turbine control system and general scope finalization.
- BOP work reduced by $207M or 56% due to significant validation of work scope placed elsewhere in the program.
- Safety Improvement work increased by $175M or 100% due to the addition of SIO's.
- Islanding work grew by $27M or 31% due to scope clarification and the development of associated cost estimates.

Overall, a variance review indicates that the larger cost increases as measured between the 2012 and 2013 Business Plans resided in the Functional groups, not the Project Bundles. This suggests that any attempt by the DR Team or Management to reduce scope must also involve a re-look of the corresponding Functional group costs as well.

2. Scope Review Process by DR Team

As noted, the DR Team is currently vetting the approved project scope. The following summarizes the process the team is using to rationalize the scope and right-size the DR Project.

a. Process for Scope Determination

The DR Project's governance for scope review establishes the following Primary Objectives:

- Successful refurbishment of Darlington Station life-limiting components in order to allow Darlington to operate for 30 years beyond the current predicted end of service life.
- The Refurbishment Project will maintain and return the unit in the condition in which it is turned over.
- A successful refurbishment project requires delivery of all core and approved non-core scope within the high confidence timeline and budget established in the RQE and as documented in the Project Business Case Summary.
- Project cost and schedule as well as post-refurbishment performance will come under extreme scrutiny due to the high profile nature of this project and its impact on OPG's reputation.